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MATHEMATICS.—*Commuting bilinear transformations and matrices.*[1]

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We present in paragraphs 1–4 an alternative approach to a theorem of K. Goldberg [1] and in paragraphs 5 and 6 a generalization of that theorem. The two sections of this paper are essentially independent.

1. Denote by Γ the group of bilinear transformations of the form

$$w\colon\ w = \frac{az + b}{cz + d}, \tag{1}$$

where a, b, c, d are rational integers and $ad - bc = 1$.

We shall establish:

Theorem 1. A necessary and sufficient condition for two transformations of Γ to commute is that each is an iterate of the same transformation of Γ.

Only the necessity of the conditions requires detailed proof.

2. We begin with the following well-known result, of which we sketch a proof (see, e.g., Forsyth [2, p. 719]):

Lemma 1. In order that two transformations of Γ should commute, it is necessary and sufficient that their fixed points should coincide.

Proof. Let

$$W\colon\ W = \frac{Az + B}{Cz + D} \tag{2}$$

be another transformation of Γ. In order that $w(W) \equiv W(w)$ we must have

$$\begin{aligned} Aa + Bc &= aA + bC \\ Ab + Bd &= aB + bD \\ Cb + Dd &= bC + dD \\ Ca + Dc &= cA + dC \end{aligned} \tag{3}$$

and conversely. These relations are equivalent to the fact that the following equations, which give the fixed points of the transformations w, W,

$$cz^2 + (d - a)z - b = 0 \tag{4}$$

$$Cz^2 + (D - A)z - B = 0, \tag{5}$$

have the same roots. To see this observe that the upper pair of (3) gives $bC = Bc$ and the lower pair gives $b(A - D) = B(a - d)$ and $c(A - D) = C(a - d)$, and so, in general,

$$\frac{c}{C} = \frac{d - a}{D - A} = \frac{b}{B}.$$

Exceptional cases, when b, c, B, C vanish or $a = d$, $A = D$ can be discussed easily.

It is easy to see that the condition presented in the lemma can be expressed in matrix language as follows: *The corresponding matrices* $\begin{pmatrix} a & b \\ c & d \end{pmatrix}, \begin{pmatrix} A & B \\ C & D \end{pmatrix}$ *should have common characteristic vectors.*

3. We require the following classical result about the units of quadratic fields:

Lemma 2. All units in a real quadratic field are of the form $\pm \epsilon^m$ where m is an integer (positive or negative or zero) and ϵ ($\neq \pm 1$) is the fundamental unit. All units in complex quadratic fields are roots of unity: ± 1 in general, $\pm 1, \pm i$ in the field $\mathrm{R}(\sqrt{-1})$ and $\pm 1, \pm\frac{1}{2}(1 \pm \sqrt{-3})$ in the case of $\mathrm{R}(\sqrt{-3})$.

Proofs of this are available, e.g., in Hecke [3] or in Reid [4, chapter 13]. The problem

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of determining the unit in $R(\sqrt{n})$, where $n > 0$, is essentially that of solving a Pell's equation.

4. *Proof of Theorem 1.* We use the canonical forms for transformations with fixed points α, β (see, e.g., Forsyth [2, p. 620]).

If α, β are finite and distinct, then

$$\frac{w-\alpha}{w-\beta} = k\frac{z-\alpha}{z-\beta} \tag{6}$$

where the "multiplier" k is given by

$$k = \frac{a+d-\sqrt{\{(a-d)^2+4bc\}}}{a+d+\sqrt{\{(a+d)^2+4bc\}}}$$

and

$$\frac{w-\alpha}{w-\beta} = K\frac{z-\alpha}{z-\beta},$$

$$K = \frac{A+D-\sqrt{\{(A-D)^2+4BC\}}}{A+D+\sqrt{\{(A+D)^2+4BC\}}}.$$

It is clear that two transformations of type (6) are compounded by multiplying the multipliers. What we have to show, therefore, is that k, K are integral powers of the same κ and that the transformation with multiplier κ belongs to Γ.

Consider the quadratic field f generated by the characteristic roots λ, μ of the matrix $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$. Since the matrix is unimodular these roots are units, and therefore of the form $\pm\epsilon^n$, where n is an integer and ϵ is the fundamental unit in case f is real, or the primitive root of unity in f, if f is complex. Hence

$$k = \frac{\lambda}{\mu} = \frac{\lambda\mu}{\mu^2} = \frac{1}{\mu^2}$$

and is therefore an integral power of ϵ, with *positive* sign.

Exactly the same holds for K in F, the field generated by the characteristic roots of $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$. However, in view of the equivalence of (4) and (5), the fields f, F are the same.

Hence we have $k = \kappa^m$, $K = \kappa^M$ for certain integers m, M. Let d be the greatest common divisor of m, M. Consider the transformation

$$Z: \frac{z-\alpha}{z-\beta} = \epsilon^d\frac{z-\alpha}{z-\beta}. \tag{10}$$

It is clear that w and W are iterates of Z, in fact

$$w = Z^{(m/d)}, \qquad W = Z^{(M/d)}$$

To show that $Z \in \Gamma$ we use the fact that there are integers m_1, M_1, such that

$$m\ m_1 + M\ M_1 = d,$$

and this implies that $w^{m_1}W^{M_1} = Z$ and, Γ being a group, we have $Z \in \Gamma$.

If α is finite, β infinite the corresponding forms are

$$\begin{aligned} w-\alpha &= k(z-\alpha), \\ k &= d/a, \quad \alpha = b/(d-a), \\ W-\alpha &= K(z-\alpha), \\ K &= D/A, \quad \alpha = B/(D-A), \end{aligned}$$

and the discussion is similar.

In the case when $\alpha = \beta$ the canonical forms for the transformation are

$$\begin{aligned} (w-\alpha)^{-1} &= (z-\alpha)^{-1} + c, \\ (W-\alpha)^{-1} &= (z-\alpha)^{-1} + C, \end{aligned}$$

and c, C being integers, the necessity of the condition of Theorem 1 is almost obvious.

5. Let A and B be 2×2 matrices whose elements are integers in a complex quadratic field F and whose determinants are units in F.

Theorem 2. Assume

(1) *that neither A nor B is similar to a matrix of the form $\zeta\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$ where ζ is a root of unity in* F *and*

(2) *that the characteristic roots of A and B do not lie in the field of the* 8th *or* 12th *root of unity.*

Under these assumptions A and B commute if and only if (apart from a unit in F*) they are powers of the same matrix in* F.

Proof. Only the necessity needs to be proved. It is sufficient to show that a matrix K exists such that $A = e_1K^m$, $B = e_2K^n$, where e_1, e_2 are units in F and m, n are rational integers. It then follows as in [1] that K can be chosen in F. The following two cases are possible:

(I) A has its characteristic roots not in F,

(II) A has its characteristic roots in F.

In case (I) the characteristic polynomial

of A is irreducible with respect to F. Hence a nonsingular matrix U exists such that

$$U^{-1}AU = \begin{pmatrix} \alpha_1 & 0 \\ 0 & \alpha_2 \end{pmatrix}$$

The numbers α_1, α_2 lie in a field Φ which is relatively quadratic with respect to F and α_1, α_2 are relative conjugate. The field Φ being complex with all its conjugates and biquadratic has one fundamental unit ϵ (see [3]). Hence, unless Φ is the field of the 8th or 12th root of unity, every unit in Φ is a power of ϵ, multiplied by a root of unity in F. If we then assume that Φ is not one of these cyclotomic fields we have

$$\alpha_1 = e_1\epsilon^m, \qquad \alpha_2 = e_1\bar{\epsilon}^m$$

where e_1 is a root of unity in F and $\bar{\epsilon}$ is the relatively conjugate number of ϵ, hence $\bar{\epsilon}$ is in Φ. Hence the coefficients of the matrix U can be chosen in Φ. Since $U^{-1}BU$ commutes with UAU it must be diagonal too. Hence the characteristic roots of B lie in Φ too and are of the form

$$\beta_1 = e_2\epsilon^n, \qquad \beta_2 = e_2\bar{\epsilon}^n,$$

e_2 a root of unity in F. Hence

$$U^{-1}AU = e_1\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}^m,$$

$$U^{-1}BU = e_2\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}^n,$$

and

$$A = e_1\left[U\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}U^{-1}\right]^m,$$

$$B = e_2\left[U\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}U^{-1}\right]^n$$

Put $U\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}U^{-1} = K$ and case (I) is completed.

(II) We may assume the characteristic roots to be different. Let ζ be the root of unity of highest period in F. Then A or B must both be similar to matrices of the form

$$U^{-1}AU = \zeta^{a_1}\begin{pmatrix} 1 & 0 \\ 0 & \zeta^{a_2} \end{pmatrix},$$

$$U^{-1}BU = \zeta^{b_1}\begin{pmatrix} 1 & 0 \\ 0 & \zeta^{b_2} \end{pmatrix}$$

Hence K can be taken as $\begin{pmatrix} 1 & 0 \\ 0 & \zeta \end{pmatrix}$.

6. The exceptional cases (1) and (2) in Theorem 2 are genuine.

(1) Any two matrices of the form

$$\begin{pmatrix} 1 & \alpha \\ 0 & 1 \end{pmatrix}, \quad \begin{pmatrix} 1 & \beta \\ 0 & 1 \end{pmatrix}$$

commute when α, β are any integers in F. However, α, β are in general, not commensurable.

(2) In the case of the field of the eighth roots of unity we observe that the matrices

$$\begin{pmatrix} 0 & 1 \\ i & 0 \end{pmatrix}, \quad \begin{pmatrix} 1 & 1-i \\ 1+i & 1 \end{pmatrix},$$

commute. The first has eighth roots of unity as characteristic roots and generates a cyclic group of order 8, while the second has as characteristic roots the units $1 \pm \sqrt{2}$ and generates an infinite cyclic group. It follows that there is no matrix of which these are integral powers. Moreover, it can be shown that any pair of commuting matrices in this case is similar to products of powers of these two.

Similar results hold in the case of the twelfth root of unity. Corresponding examples are

$$\begin{pmatrix} 0 & 1 \\ 1 & -i \end{pmatrix}, \quad \begin{pmatrix} 2+i & 2 \\ 2 & 2-i \end{pmatrix}.$$

They commute and have as characteristic roots twelfth roots of unity, and the units $2 \pm \sqrt{3}$.

7. *Generalizations.* There are several possible directions in which the results of this paper can be generalized; some of these have been investigated by E. C. Dade [5].

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BOTANY.—*New grasses from Mexico.* ERNEST R. SOHNS, U. S. National Museum. (Communicated by Agnes Chase.)

(Received July 27, 1956)

In the course of routine identification of miscellaneous collections of grasses from Mexico, six new taxa were discovered and the original descriptions of two species required emendation. The new entities and emendations are presented in this paper.

Panicum clivum Sohns, sp. nov.

Figs. 1–8

Gramen perenne; culmi 20–50 cm alti, decumbentes, graciles; vaginae internodiis breviores, inferiores striatae, papilloso-pilosae, superiores marginibus papilloso-pilosis; ligula circiter 1 mm longa; laminae 2–8.5 cm longae, 3–12 mm latae, omnes pubescentes, margines papilloso-pilosis; panicula 5–8 cm longa, 2–8 cm lata, ramis brevibus, inferiores 4.5 cm longi; spiculae 2.3–2.7 mm longae; gluma prima 0.5–0.9 mm longa, lata, rotundata, enervis; gluma secunda et lemma sterile subaequans; lemma fertile circiter 2–2.2 mm longum, 7-nervis; lemma sterile vacuum; lemma fertile 2.1–2.4 mm longum, 1.0–1.1 mm latum, glabrum, 5-nervis; palea lemma sterile aequans; staminia 3, antherae 0.4 mm longae; lodiculae 2, membranaceae, 0.2 mm longae; caryopsis circiter 1.5 mm longa, 1 mm lata.

Perennial; culms decumbent at first and/or second nodes, but not rooting, 20–50 cm tall, glabrous; sheaths shorter than the internodes, the lower loose, striate, papillose-pilose, upper sheaths papillose-pilose on the margin and sparingly pilose between the nerves, a dense ring of hairs on the collar across the back; ligule a fringe of hairs about 1 mm long; blades to 8.5 cm long, 3 to 12 mm or more wide, sometimes cordate-clasping, pubescent on both surfaces, papillose-pilose on the margins, especially near the base; inflorescence a narrow exserted panicle, 5–8 cm long, 2–8 cm wide, panicle branches mostly short, the lower sometimes 4.5 cm long, the axes and branches glabrous; spikelets 2.3–2.7 mm long, averaging 2.47 mm (measurements on 60 spikelets); first glume 0.5–0.9 mm long, broad, rounded, clasping base of spikelet, nerveless or sometimes with a faint median nerve; second glume and sterile lemma about 0.1 mm shorter than the fertile lemma; both 7-nerved, very sparingly short-pilose with scattered hairs; sterile lemma with a membranous palea about 1 mm long; fertile lemma 2.1–2.4 mm long, about 1–1.1 mm wide, smooth and shining, 5-nerved, the nerves visible as faint white lines; palea as long as the lemma; stamens 3, anthers 0.4 mm long; lodicules 2, membranous, spatulate, 0.2 mm long; caryopsis about 1.5 mm long and 1 mm wide.

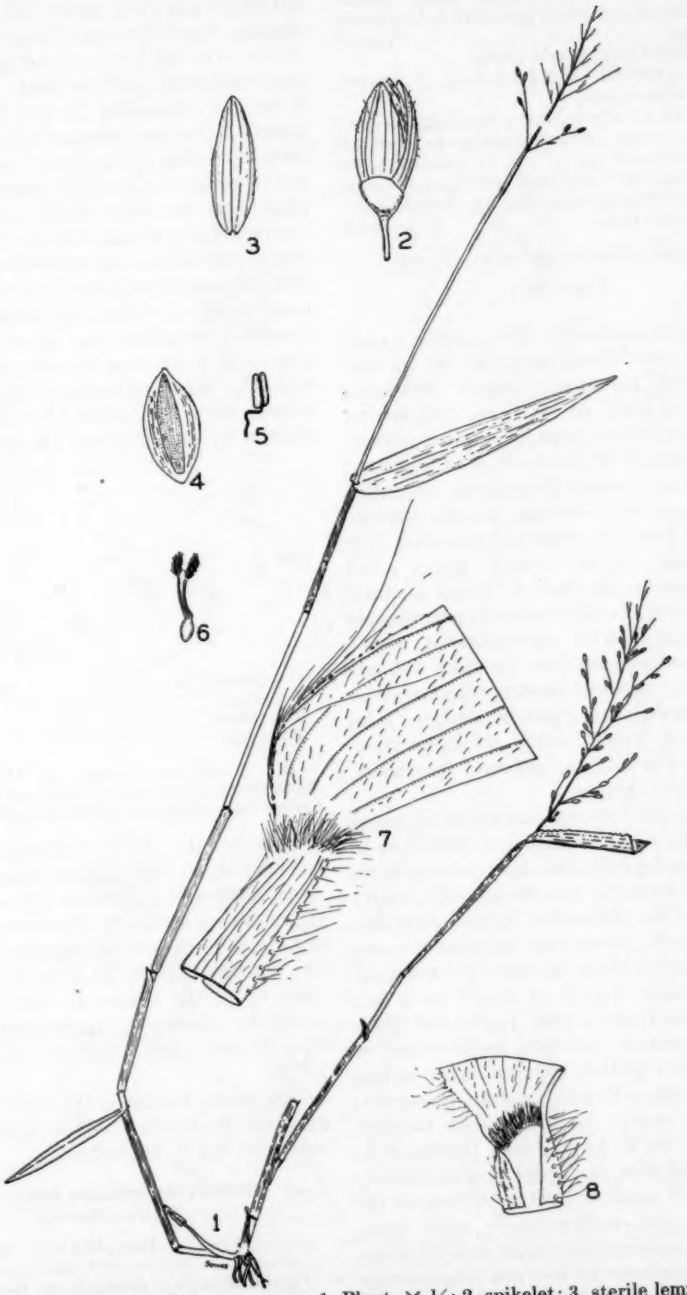
Type in the U. S. National Herbarium, no. 2041588, collected "on mossy limestone boulder; ravine slopes above Tepeoco, 3.5 miles from Zacualtipan on road to Tianguistengo," State of Hidalgo, altitude 2,100 meters, March 20, 1947, by H. E. Moore, Jr. (no. 2371). Additional specimens examined: HIDALGO: Palo Hueco, *Moore* 2694. MÉXICO: Cañado de Nanchititla, *Matuda* 30818.

This species belongs in the subgenus *Dichanthelium*, section *Commutata*, and is related to *P. albomaculatum*, *P. hintonii*, and *P. joorii*. A key to the species of this section follows the discussion of *P. albomaculatum*. The distribution of the species in this section is shown in Fig. 9.

In the course of examining collections of *P. albomaculatum* Scribn. (U. S. Dept. Agr. Div. Agrost. Circ. **19:** 2. 1900) in the U. S. National Herbarium, including the type and the original description, it became apparent that the original description required emendation.

In his description Scribner stated that the spikelets are "2.5 mm long; . . ." Spikelets on the type specimen measured 2.5 to 3.0 mm in length (the average of 25 spikelets: 2.7 mm). No measurements were given for the length of the panicle which is found to vary from 12 to 18 cm. The branches of the panicle are relatively stiff and somewhat ascending. The blades are described as "scabrous on the nerves below, glabrous above, . . ." Seven collections of *P. albomaculatum* have sheaths and blades which are papillose-pilose in varying degrees of density. The spikelets of these pubescent specimens are in the same size range as the sparingly pubescent spikelets of the type. The average length of 100 spikelets is 2.66 mm.

The new species may be separated from other species in this section by the following key.



FIGS. 1–8.—*Panicum clivum* Sohns, sp. nov.: 1, Plant, × ½; 2, spikelet; 3, sterile lemma; 4, fertile lemma (palea visible); 5, stamen; 6, ovary; 7, junction of blade and sheath; 8, view of ligule. Figs. 2–6 and 8, × 8; fig. 7, × 16. Drawn from the type specimen.

Blades asymmetrical and falcate; culms decumbent; first glume about one-third as long as the spikelet ..... *P. joorii*
Blades symmetrical, nearly linear.
Spikelets glabrous, 2.2–2.4 mm. long. . *P. hintonii*
Spikelets pubescent.
Spikelets 2.5–3 mm long (averaging 2.7 mm); plants erect; panicles open, many-flowered, 12 to 18 cm long ..... *P. albomaculatum*
Spikelets 2.3–2.7 mm long (averaging 2.4 mm); plants decumbent-straggling; panicles small, 5 to 8 cm long ..... *P. clivum*

Panicum crateriferum Sohns, sp. nov.

Figs. 10–22

Gramen perenne; culmi basi repentes, e nodis radicantes, dein erecti, usque ad 35 cm alti, graciles, nodi pubescenti; vaginae internodiis breviores, striatae, ad os dense pubescentis; ligula circiter 0.5 mm longa; laminae lanceolatae, 2–5 cm longae, 5–12 mm latae, subtus glabrae, supra sparsim hirsutis tuberculatis adspersae; racemi 6, usque ad 2 cm longi; spiculae geminae, inferiores plerumque reductae, superiores 2.3–3 mm longae. Spicula superna: gluma prima 1.7 mm longa, valide 3-nervis, versus summam papilloso-pilosa, margine hyalina; gluma secunda 2.5 mm longa, 5-nervis, papilloso-pilosa; lemma sterile (interdum cum flore masculo) 2.7 mm longum, parce papillose-pilosum, margines dense papilloso-pilosis, cum glandulis duobus; palea membranacea; lemma fertile oblongo-ovatum, circiter 1.6 mm longum, glabrum; staminia 3, antherae 0.9 mm longae.

Perennial, with wiry, creeping culms producing upright culms at the nodes; culms slender, up to 35 cm tall, nodes pubescent, internodes glabrous or sparingly pubescent near the summit; sheaths shorter than the internodes, striate, glandular-spotted, densely pubescent at the summit across the back; ligule a ciliate rim about 0.5 mm long; blades lanceolate, 2 to 5 cm long, 5 to 12 mm wide, asymmetrical at base, junction of blade and sheath scarcely petiolate, lower surface of blade glandular spotted, glabrous, upper surface sparsely papillose-hirsute, midrib prominent; inflorescence usually consisting of six racemes, averaging 2 cm in length, each bearing 4 to 10 paired spikelets, the lower spikelet usually reduced, a few papillose hairs at the base of the raceme, the axis papillose-pilose; rachis terminated by a single spikelet; upper spikelet of the paired spikelets from 2.3 to 3 mm long (average length of 46 spikelets: 2.68 mm). Reduced lower spikelet of pair: first glume with a pronounced, clasping hyaline margin, 3-nerved, papillose-hirsute over the back; second glume 5-nerved, papillose-hirsute over the back; upper spikelet of the pair (averaging 2.6 mm in length): first glume 1.7 mm long, strongly 3-nerved, papillose-pilose on the back near the tip, margins hyaline; second glume 2.5 mm long, 5-nerved, papillose-pilose over the back; sterile lemma 2.7 mm, 5-nerved (often a faint vascular bundle may be seen on the margin on each side of the lemma), sparingly papillose-pilose over the back, but more densely so along the margins, with two gland-like structures, one on each side of the keel about 1 mm from the tip; palea very thin, enclosing three rudimentary stamens; fertile lemma oblong-oval, about 1.6 mm long, smooth; stamens 3, anthers about 0.9 mm long.

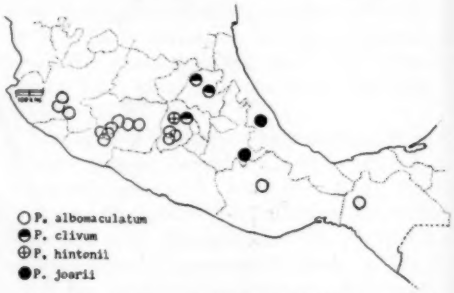


FIG. 9.—Map of portion of Mexico showing distribution of species of *Panicum* in the section *Commutata*, subgenus *Dichanthelium*.

Type in the U. S. National Herbarium, no. 1983658, on "steep grassy slopes and narrow ravine with open pine woods and scattered oaks on granitic soil at km 339–40 between Acahinzotla and Agua de Obispo, on highway to Acapulco, alt. ca. 3000'" State of Guerrero, October 1, 1949, by H. E. Moore, Jr. (no. 5148). Other specimens examined: GUERRERO: Montes de Oca, *Hinton* 10801; Galeana, *Hinton* 14646, 14725.

This species belongs in the section *Stolonifera*, subgenus *Eu-Panicum* and is related to *P. biglandulare* and *P. pulchellum*.

Panicum biglandulare Scribner and Smith, emended

Figs. 24–31

Perennial, culms prostrate or ascending, producing branches from the nodes, 40 cm to more

FIGS. 10–22.—*Panicum crateriferum* Sohns, sp. nov.: 10, plant × ½; 11, node; 12, paired spikelets; 13, sterile lemma and fertile lemma; 14, palea of sterile lemma; 15, first glume of lower spikelet; 16, second glume of lower spikelet; 17, sterile lemma of lower spikelet; 18, fertile lemma of lower spikelet; 19, sterile lemma of upper spikelet; 20, fertile lemma of upper spikelet; 21, pistil and 22, anther. Figs. 11–14, × 8; all others × 16.

than 1 meter tall; nodes swollen and glabrous; sheaths shorter than the internodes, striate, sparingly pilose, the overlapping half of the sheath densely papillose-pilose, the pilose margins alternating with each node from base to tip; ligule a membranous rim, finely ciliate at the summit, usually less than 0.5 mm long; blades with a petiole about 1 mm long, a line of hairs across the back at the collar, lanceolate, acuminate, 3 to 9 cm long, 0.9 to 22 mm wide, the base asymmetrical, from sparingly to densely papillose-pilose on both surfaces, margins antrorsely scabrous; inflorescence exserted, composed of usually six to ten somewhat distant racemes, 0.6–2.5 cm long; spikelets borne on one side of the rachis, usually paired, the lower sometimes undeveloped, 2.5 to 4 mm long (average length of 147 spikelets: 3.33 mm); first glume 1.3–1.8 mm, 3-nerved, ovate, papillose-pilose over the back and near the tip; second glume 1.3–3.2 mm long, 5-nerved, sparingly papillose-pilose over the back and on the margins; sterile lemma 2.5 to 4 mm long, 7-nerved (marginal nerves sometimes scarcely visible), minutely scaberulous and sparsely papillose-pilose over the back and on the margins, provided with two raised, gland-like structures about 1 mm from the tip, one on each side of the median nerve; fertile lemma smooth, shining, 2–2.5 mm long; anthers 3, well developed, 1–1.3 mm long.

According to Scribner and Smith's original description the margins of the sheaths "are clothed with glands bearing branching hairs; . . . " The margins of the sheaths are only papillose-pilose. The spikelets are also described as "almost sessile, 2 lines long [4 mm]; . . . " The average length of the spikelet in the type specimen is 3.70 mm (measurements on 24 spikelets). The spikelets varied in length from 3 to 4 mm. The specimen collected by Santos (No. 3437) in Oaxaca has smaller spikelets, on the average, than those specimens collected in Chiapas and Guatemala. The spikelets of this collection range in size from 2.5 to 3 mm, the average length of 21 spikelets, 2.6 mm. The specimen is referred to *P. biglandulare*; its small stature and small spikelets are probably responses to edaphic conditions.

The distribution of *P. pulchellum*, *P. biglandulare* and *P. crateriferum* is shown on the map (Fig. 23).

Specimens examined: MÉXICO: CHIAPAS: near Piñabete, *Nelson* 3781 (type); Mount Pasitar, *Matuda* 316; Montecristo, *Matuda* 2006; Monte Bello, *Carlson* 2330. OAXACA: Santa María de Lovani, San Juan de Petlapa, *Santos* 3437.

GUATEMALA: Cobán, *von Türckheim* 1342, 1956; hills between Cobán and Tres Cruces, *Standley* 90263.

Species of the section *Stolonifera*, subgenus *Eu-Panicum* may be separated by the following key:

Nodes glabrous; blades sparingly to densely long papillose-pilose on both surfaces; spikelets 3–4 mm long . . . . . *P. biglandulare*

Nodes pubescent

Spikelets not over 2 mm long; blades short, ovate-lanceolate, usually not over 4 cm long *P. pulchellum*

Spikelets 2.3–3.0 mm long; blades lanceolate, pale green, sparsely pilose on both surfaces *P. crateriferum*

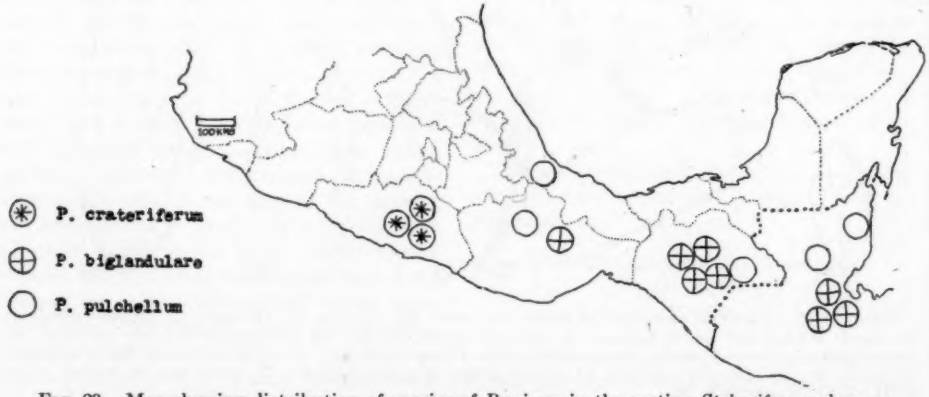


FIG. 23.—Map showing distribution of species of *Panicum* in the section *Stolonifera*, subgenus *Eu-Panicum*.

FIGS. 24–31.—*Panicum biglandulare*: 24, Plant, × ½; 25, junction of blade and sheath; 26, short raceme of spikelets with portion of rachis; 27, pair of spikelets; 28, first glume; 29, second glume; 30, sterile lemma; 31, fertile lemma. All figs. × 8, except 28 and 31, × 16. Drawn from *Türckheim* 1342.

Muhlenbergia matudae Sohns, sp. nov.

Figs. 32–38

Gramen perenne; culmi erecti, 20–50 cm alti, graciles, ad nodos hispidis, vaginae inferiores papyraceae, superiores internodiis breviores, glabrae; ligula truncata, circiter 1 mm longa; laminae 4–10 cm longae, 0.8–1.5 mm latae, utrinque scabrae, margine scabrae; panicula exserta, patula, pauciflora; usque ad 15 cm longa; spiculae 3.5–6.3 mm longae; gluma prima 1.5–2.1 mm longa, 1-nervis, carina scaberula, arista circiter 0.5 mm longa; lemma 2.6–3.8 mm longum, 3-nervis, callo pilis brevis, ad margines parce pilis, carinis parce scabris versus summam, arista 0.9–2.6 mm longa, scabra; palea lemma aequans, bicarina, glabra; staminia 3, antherae 1.5 mm longae; lodiculae 0.

Perennial; loosely tufted, culms 20–50 cm tall, slender, erect, hispid below the nodes; sheaths of basal blades papery and straw-colored, glabrous, upper sheaths shorter than the internodes, glabrous; ligule a truncate membranous rim about 1 mm long; blades mostly basal, 4–10 cm long, 0.8 to 1.5 mm wide, scabrous on both surfaces and on the margins, loosely involute when dry, tips slightly flexuous; inflorescence an exserted, loose, open, few-flowered panicle, up to 15 cm long, the spikelets borne singly at the ends of the slender branches; spikelets 3.5–6.3 mm long (including the awn), the lowermost spikelets about 3.5–3.8 mm long, the terminal spikelet of each first-order branch largest, from 3.9–6.3 mm (average length 4.9 mm) long; first glume 1.5–2.1 mm long, 1-nerved, slightly scaberulous on the keel toward the awn-pointed tip; second glume 1.9–2.8 mm long, 1-nerved, scaberulous on the keel toward the abruptly awn-pointed tip, the awn about 0.5 mm long; lemma 2.6–3.8 mm long, 3-nerved, the lateral nerves sometimes obscure, a few short hairs on the callus and on the margins, sparingly scabrous on the keel toward the tip, awn 0.9–2.6 mm long, antrorsely scabrous; floret readily deciduous, leaving the glumes at the end of the branchlet; palea as long as the lemma, 2-keeled, glabrous; stamens 3, anthers 1.5 mm long; styles 2, free to top of ovary; stigmata plumose; lodicules 0.

Type in the U. S. National Herbarium, no. 2079186, collected "en ladera húmeda, orilla de bosque mixto de pinos y oyamel, Lago de Zempoala, Edo. de Morelos" altitude 3,000 meters, October 7, 1951, by Dr. E. Matuda (no. 25601).

This species is named in honor of Dr. Eizi Matuda, good friend and excellent collector of Mexican plants.

This species is related to *M. arizonica* and *M. arenicola*. It may be separated from these species by the following key:

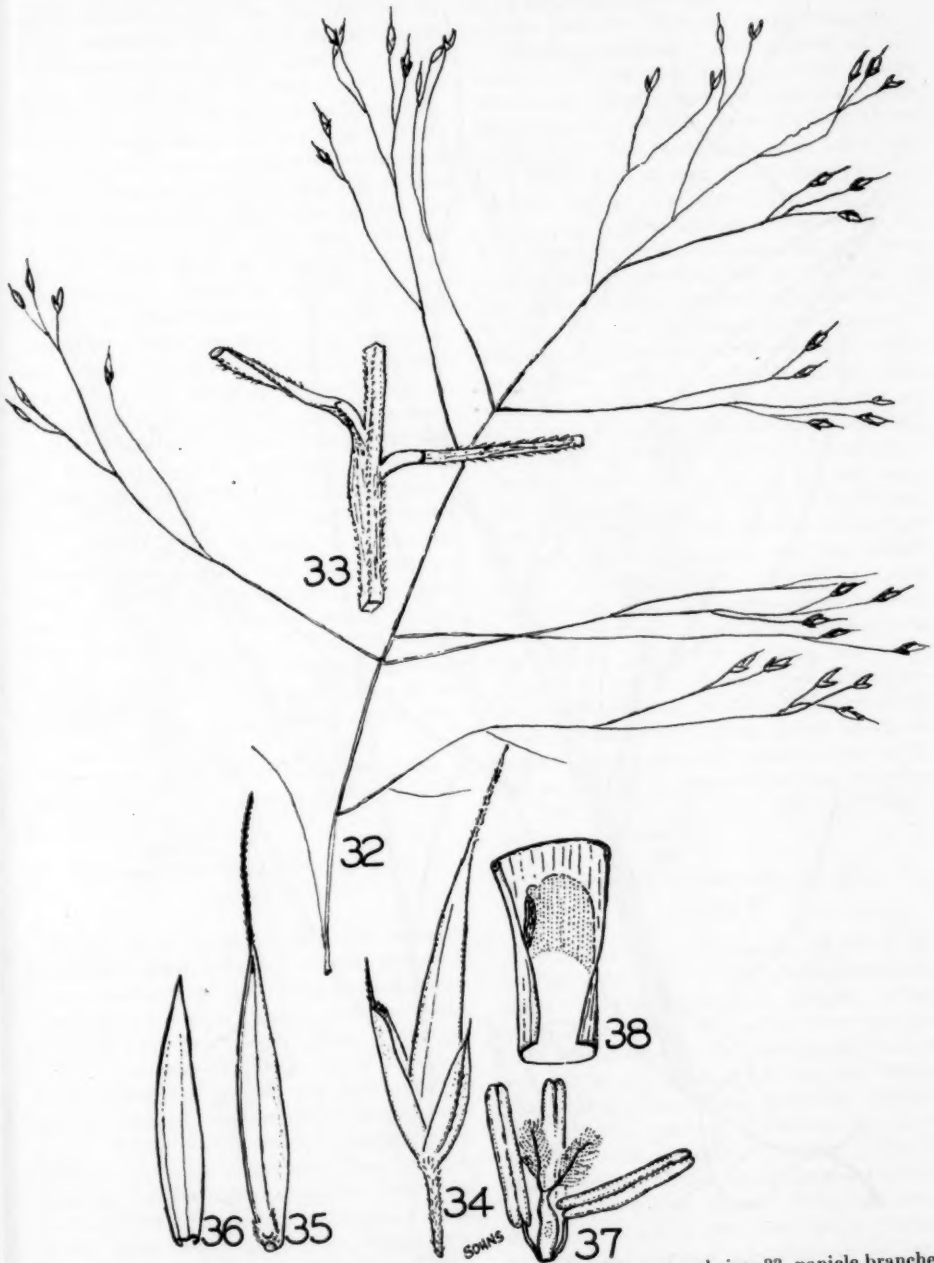
Blades flat or only loosely involute, ligules 1–2 mm long.
  Glumes subequal, the first 1.5–2.1 mm, the second 1.9–2.8 mm long, awn-pointed, the second glume with an awn about 0.5 mm long; panicle branches long, few-flowered ..... *M. matudae*
  Glumes equal, about 1 mm long; panicle branches short, many-flowered ..... *M. arizonica*
Blades involute; ligule 2.5–3 mm long, firm; glumes 2.3–2.5 mm long; lemma about 3 mm long, scaberulous at tip; panicle branches short, many-flowered ..... *M. arenicola*

Calamagrostis mcvaughei Sohns, sp. nov.

Figs. 39–46

Gramen perenne; rhizomate; culmi 50–100 cm alti, graciles, glabri; vaginae internodiis longiores, aretae, scaberulae, ad os parce pilosis; ligula rotundata, membranacea, 1–1.2 mm longa; laminae 10–30 cm longae, subtus scabrae, supra valide nervis prominulis percursae, in collo parce strigosis; panicula densiflora, laxa, pyramidata, ramis gracilibus, verticillatis, flexuosis; spiculae 4–5 mm longae; gluma prima 3.4–4.2 mm longa, 1-nervis, carina scaberula ad summam; gluma secunda 4–5 mm longa, ceteroqui primam similis; lemma 3.4–4.1 mm longum, 5-nervis, scaberulum, 2- (interdum 4-) denticulata, dorso medium aristatum, 6–8 mm longa, geniculata; callo pilis copiosis, lemmam dimidio breviore; palea membranacea, lemmam subaequans; staminia 3, antherae circiter 2 mm longae; lodiculae 2; rachilla producta.

Perennial, rhizomatous, tufted; culms 50–100 cm tall, slender, erect, glabrous; sheaths overlapping at base, straw-colored, scaberulous and slightly pilose, especially toward the collar; ligule a rounded membranous rim 1.0–1.2 mm long; blades 10 to 30 cm or more long, convolute when dry, scabrous on the lower surface, strongly ribbed on the upper surface and pilose on the nerves; collar sparsely strigose on the margins at the junction of the blade and sheath; panicle many-flowered, open, pyramidal, the branches slender, flexuous, verticillate, the lower branches



FIGS. 32–38.—*Muhlenbergia matudae* Sohns, sp. nov.: 32, Panicle, natural size; 33, panicle branches; 34, spikelet; 35, lemma; 36, palea; 37, essential organs; 38, ligule. All figures, except 32, × 16. Drawn from type specimen.

FIGS. 39–46.—*Calamagrostis mcvaughei* Sohns, sp. nov.: 39, Plant, × ½; 40, spikelet; 41, floret; 42, anther; 43, lodicule; 44, cross section of blade; 45, external view of collar at junction of sheath and blade; 46, inside view of ligule, one-half of blade, sheath and ligule removed. Figs. 42 and 44, × 16, all others, × 8. Drawn from the type specimen.

bearing spikelets at the tips, the branches antrorsely scaberulous, glabrous in the axils; spikelets spreading in anthesis, pale-green to reddish-purple, 4–5 mm long (average length of 15 spikelets: 4.4 mm); first glume 3.4–4.2 mm long, 1-nerved, scaberulous on the keel toward the tip; second glume 4–5 mm long, 1-nerved, scaberulous on the keel toward the tip; lemma with an awn 6–8 mm long, inserted about the middle, one (or indistinctly twice) geniculate, exserted, antrorsely scaberulous, the lemma 3.4–5.1 mm long, 5-nerved, scaberulous on the back and scabrous on the keel toward the tip, apex with 2 (sometimes 5) setaceous teeth, callus hairs abundant, about half as long as the lemma; palea membranous, thin, about as long as the lemma; stamens 3, anthers about 2 mm long; lodicules 2, slightly swollen at the base, terminal half thin and flattened; rachilla prolonged, pilose, the hairs extending to the tip of the second glume.

Type in the U. S. National Herbarium, no. 2118496, collected in "Sierra de Manantlan (15–20 miles southeast of Autlan), near Aserradero El Cuartón, elevation 2500 m; steep slopes near summits, in pine-oak-fir forests," in the State of Jalisco, November 2, 1952, by Rogers McVaugh (No. 13853). Additional specimen examined: JALISCO: northeastern slopes of the Nevado de Colima, below Cañoa de Leoncito, *McVaugh* 13468.

This taxon is related to *C. tolucensis* and is named in honor of Dr. Rogers McVaugh, of the University of Michigan.

Calamagrostis valida Sohns, sp. nov.

Figs. 47–55

Gramen perenne; caespitose, culmi usque ad 65 cm alti; vaginae inferiores efoliatae, superiores internodiis longiores, scaberulis; ligula membranacea, 2.5–3 mm longa; laminae 8–20 cm longae, usque ad 8 mm latae, supra pilosis, subtus glaberrimis; panicula densiflora, 15–25 cm longa, ramis verticillatis; spiculae 5–6 mm longae, in callo pilis copiosis, usque ad 4 mm longis; gluma prima circiter 4 mm longa, 1-nervis, carina scaberula, ceteroqui glaberrima; gluma secunda usque ad 5.5 mm longa, 3-nervis, glaberrima; lemma circiter 4.5 mm longum, 5-nervis, 2-denticulata, arista usque ad 6 mm longa, dorso medium aristatum, columna laxe torta, exserta, leviter geniculata; palea 3.8–5 mm longa, bicarinata, bifida, membranacea; staminia 3, antherae 3.5–4 mm longae; lodiculae 2, 0.5–0.8 mm longae; rachilla producta, 1.8–2 mm longa, longe-pilosi.

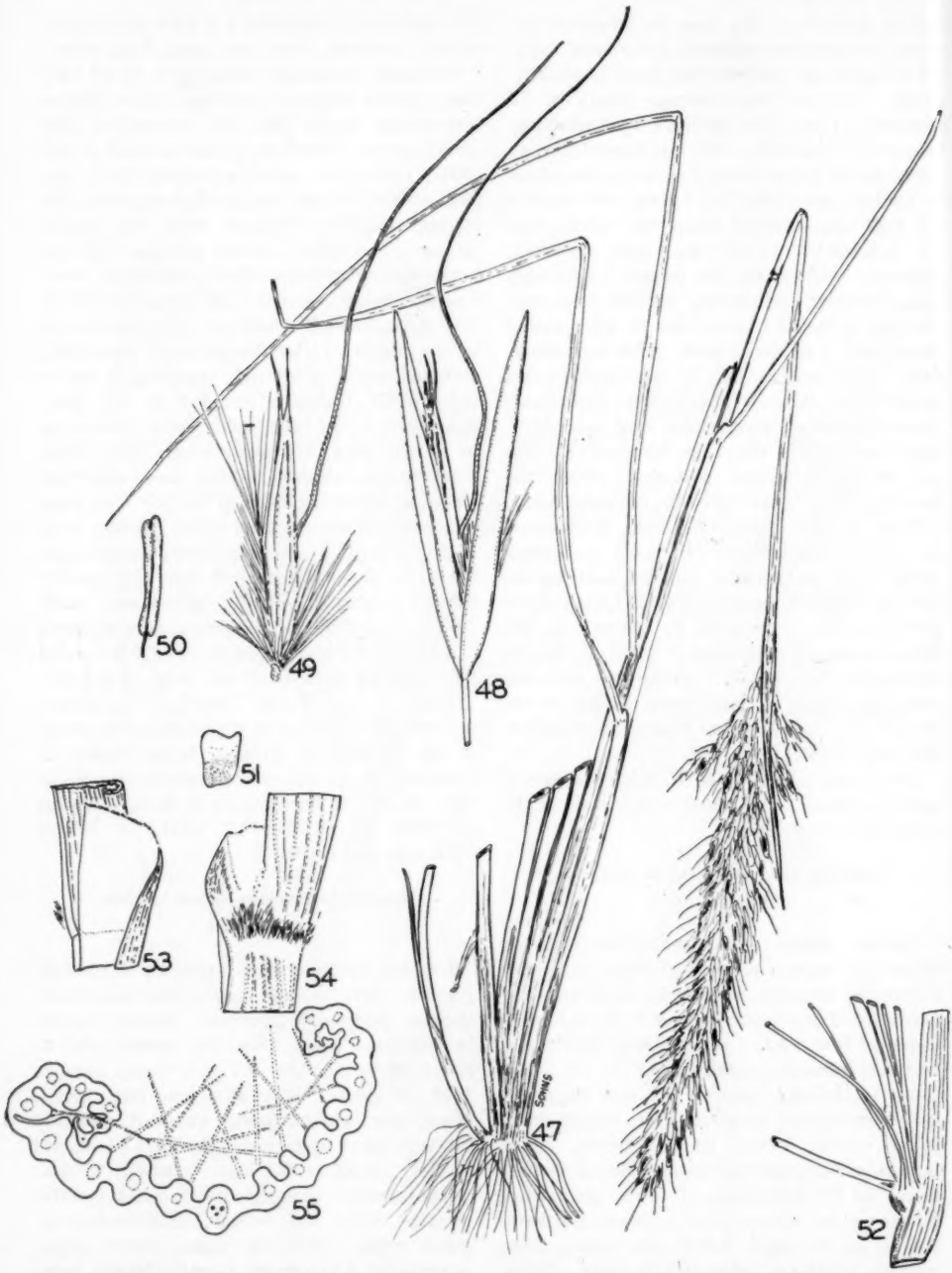
Perennial; caespitose, culms up to 65 cm tall; basal sheaths bladeless, glabrous, upper sheaths scaberulous, longer than the internodes, pale pinkish-purple, hirtellous across the back at the collar; ligule firm, membranaceous, 2.5–3 mm long, blades 8–20 cm long, up to 8 mm wide, the margins slightly convolute when dry, upper surface pilose, lower surface glabrous, the tip long-attenuate; terminal blades sometimes overtopping the inflorescence; inflorescence 15–25 cm long, dense, branches fascicled, 1.5–2 cm distant in the center of the inflorescence, alternately arranged, branches probably spreading in anthesis, slightly purplish, included at the base; spikelets 5–6 mm long; callus hairs copious, up to 2.4 mm long; first glume about 4 mm long, 1-nerved, scaberulous on the keel, otherwise glabrous; second glume up to 5.5 mm long, 3-nerved, glabrous; lemma about 4.5 mm long, 5-nerved, with 2 setaceous teeth, awned from the back, the awn up to 6 mm long, loosely twisted, exserted, slightly geniculate; palea 3.8 mm long, 2-keeled, membranaceous; stamens 3, anthers 3.8–4 mm long; lodicules 2, 0.5–0.8 mm long; rachilla joint 1.8–2 mm long, long-pilose.

Type in the U. S. National Herbarium, no. 2118491, collected on the northeastern slopes of the Nevado de Colima, below Cañoa de Leoncito; steep cut-over mountainsides in fir zone at head of Barranca de la Rosa, elevation ca. 2800 m, October 10, 1952, by Rogers McVaugh (no. 13410).

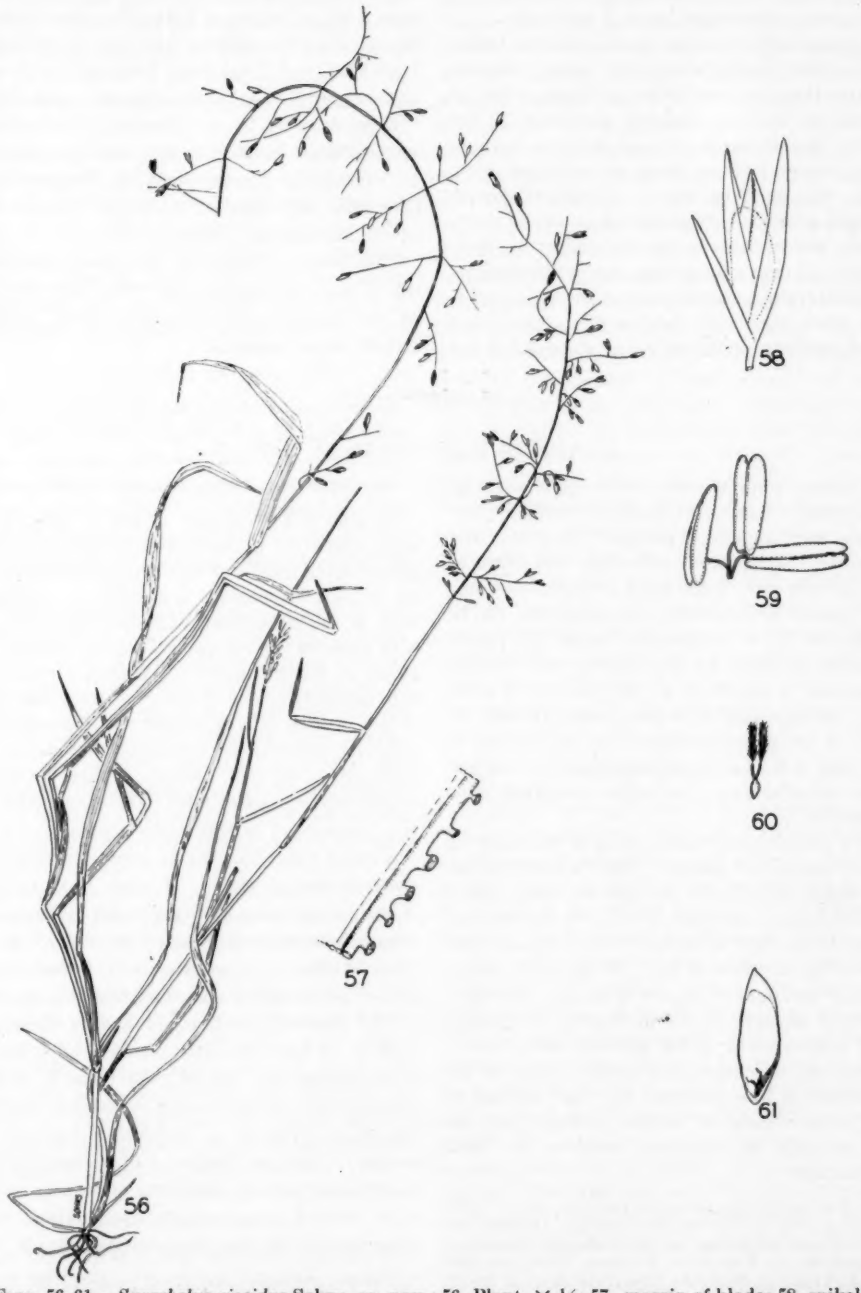
Sporobolus viscidus Sohns, sp. nov.

Figs. 56–61

Gramen annuum; culmi usque ad 50 cm alti, graciles, infra nodos crateriformi-tuberculati; vaginae internodiis breviores, glabrae, carinis tuberculatae, nervi culmorum sparse tuberculatae; ligula ciliolata, 0.5 mm longa; laminae 4–20 cm longae, usque ad 6 mm lata, tenuis, plana, supra glabra, subtus scaberula, margines tuberculatis et scaberrimis; panicula 15 cm vel longior, rachis tuberculata, glabra, viscida; ramis brevibus, rigidis, sparse ramosis, viscidis; spiculae 3.5–4 mm longae, pallido-purpurea; gluma prima 1.9–3 mm longa, enerve; gluma secunda 2.5–4 mm longa, 1-nervis; lemma usque ad 4 mm longum, 1-nerve; palea lemma aequans vel longior, valide bicarina; staminia 3, antherae



FIGS. 47–55.—*Calamagrostis valida* Sohns, sp. nov.: 47, Plant, × ½; 48, spikelet; 49, floret; 50, anther; 51, lodicule; 52, node on the axis of the raceme; 53, ligule, median adaxial view; 54, collar at junction of the blade and sheath; 55, cross-section of blade. Figs. 48–50, 52–55, × 8; 51, × 20. Drawn from the type specimen.



FIGS. 56–61.—*Sporobolus viscidus* Sohns, sp. nov.: 56, Plant, × ½; 57, margin of blade; 58, spikelet; 59, stamens; 60, ovary; 61, caryopsis (pericarp free at tip and base). All figures, except 56, × 8. Drawn from the type specimen.

1.8–2.2 mm longae; lodiculae 2, 0.2 mm longae; caryopsis circiter 3 mm longa, 1 mm lata.

Annual; culms up to 50 cm tall, slender, tuberculate-crateriform below the nodes; sheaths shorter than the internodes, glabrous, a line of glands on the keel, sparsely glandular on the lateral nerves; ligule a fringe of hairs, 0.5 mm long; blades 4–20 cm long, up to 6 mm wide, thin, flat, glabrous above, scaberulous below, margins near the base glandular, otherwise short-ciliate, the margins of the tip slightly inrolled; panicle 15 cm or more long, rachis tuberculate-glandular, the branches short, stiff, viscid; spikelets 3.5–4 mm long, pale-purplish; first glume 1.9–3 mm long, nerveless; second glume 2.5–4 mm long, 1-nerved; lemma up to 4 mm long, 1-nerved; palea firm, as long as or longer than the lemma, strongly 2-keeled, splitting when mature; stamens 3, anthers 1.8–2.2 mm long; lodicules 2, 0.2 mm long; caryopsis about 3 mm long and 1 mm wide.

Type in the U. S. National Herbarium, no. 2181966, collected "en matorral seco, 550 m. de altitud, La Junta, cerca de Tingambato, Diciembre 20, 1953," Estado de Mexico, by Dr. E. Matuda (no. 29813).

This taxon is related to *S. hintonii* Hartley, but it may be distinguished from that species by the narrow, short-branched, viscid panicle and the larger spikelets.

LEATHER RESEARCH AT NBS

In many respects leather is a unique material, possessing a number of desirable physical properties, such as tearing strength, flexibility, and porosity, that make it particularly well suited to use in shoes, gloves, and other articles of clothing. For specific applications, these properties can be controlled to a considerable extent by proper selection of skins, tanning agents, and finishing processes. A knowledge of the structure of collagen, the basic leather forming protein of hides, as well as an understanding of the mechanism of tanning, is thus of direct importance to tanners, shoe manufacturers, and other industrial users of leather.

To provide basic information of this kind for Government and industry, the National Bureau of Standards has, over the past 40 years, carried on an extensive program of research and development in the field of leather.[1] This program, now under the direction of Dr. J. R. Kanagy, has included fundamental studies of collagen, development of concepts for the mechanism of tanning, and measurement of the physical and chemical properties of collagen and leather. Much of the information thus obtained has been applied to the improvement of leather products and the development of standard methods for their evaluation.

[1] For further details and a bibliography of NBS publications in the leather field see, *Leather research and technology at the National Bureau of Standards*, by Everett L. Wallace, NBS Circ. 560. 1955. Available from the Superintendent of Documents, U. S. Government Printing Office, 15 cents.

FUNDAMENTAL PHYSICOCHEMICAL STUDIES

Because of the complex nature of collagen, a large proportion of the Bureau's leather investigations have combined both physical and chemical studies. An example is a series of investigations of the interactions of leather and collagen with water in various forms. Leather excels in its ability to transfer water vapor from a region of high humidity to one of lower humidity. Because of the relation of this property to shoe comfort and the removal of perspiration from shoes, water-vapor transfer through leather has been extensively studied at NBS.[2] The strong adsorptive capacity of leather and collagen for water and water vapor also has an important effect on the properties of leather. This has led to a series of studies on water adsorption and its variation with temperature, tannage, and other factors. These studies are being extended to include heats of wetting of leather and other fibrous polymers.

The physical constants of leather fibers are perhaps of less immediate practical importance. Nevertheless, they are of great value in understanding the complex nature of collagen and the processes involved in converting collagen to leather. In general, studies of fiber constants are made under varying conditions of tannage, moisture content, temperature, composition, and other factors, so that extensive data result.

[2] *Water vapor permeability of leather*, NBS Technical News Bull. 34: 163. Nov. 1950.

To learn more about the thermodynamic properties of leather, data have been obtained on its density, compressibility, expansivity, and specific heat. In the course of this work, investigators encountered interesting phenomena which are being explored further. For example, the expansivity measurements led to studies of shrinkage rates, with resulting data on heats and entropies of activation. Likewise, compressibility measurements at the high pressures required for solid materials led to similar studies on synthetic polymers. Data on specific heats are now being accumulated in connection with basic studies on interactions of moisture and leather.

BASIC CHEMISTRY OF COLLAGEN

Skin collagen, being a natural fibrous protein, is a highly complex polymer that occludes extraneous materials, such as fats, salts, and other proteins. Thus, fundamental chemical studies of collagen first required investigation of methods for removing extraneous materials so that a chemically reproducible purified collagen might be prepared.

The chemistry of the purified collagen that was finally obtained has been intensively studied, providing data that should be of great value in determining its structure and the mechanism of tanning. Besides studying relatively simple chemical reactions, such as esterification, deamination, and various tanning procedures, the Bureau has determined the combining weights and the reactive basic groups. It has also studied the amino acid structure and the amide nitrogen content of collagen.

Recently, a rapid chromatographic method was developed for determining the amino acid content of collagen.[3] This quantitative technique can be applied not only to collagen itself but also to its derivatives and degradation products. In contrast to other methods currently employed, it enables the analyst to follow with a high degree of detail the reactions and changes in which collagen may be involved. It is thus expected to provide a useful tool that will aid in further understanding the structure of collagen and the properties of leather.

PHYSICAL PROPERTIES

The behavior of leather in service is largely determined by the physical properties of the leather matrix. Mechanical properties that have been investigated extensively include tensile strength, stretch, tearing strength, stiffness, bursting strength, rigidity, and flexural resistance. Investigations of thermal properties have involved shrinkage temperature, area stability, and thermal conductivity. Other studies have dealt with electrical resistance, dielectric constant, and structural properties such as pore-size distribution in the fibers and leather.

Recently, fundamental information regarding the structure of leather and collagen fibers was obtained from studies of pores in leather.[4] Pressure porosimeter and electron microscope studies revealed the presence of large numbers of extremely small pores—less than a millionth of an inch in radius—in both leather and collagen. Quantitative information was obtained on pore-size distribution within the individual collagen fibrils. These data should aid the leather technologist in understanding the swelling and shrinkage accompanying water-leather interactions. They are also expected to shed additional light on the ability of leather to transmit or absorb water vapor, tannins, or impregnants. The permeability of leather to water vapor, which makes it so well suited to use in footwear, is undoubtedly related to the presence of pores.

LEATHER TECHNOLOGY

In 1924, a survey by the U. S. Department of Commerce stated that 40 percent of the vegetable tanning materials consumed in the United States in 1922 were imported. It also pointed out that 99 percent of the chrome ore used in the United States at that time came from abroad. In view of the obvious importance of a substitute tanning material to the national economy, the Bureau initiated research on synthetic tanning agents.

Representative syntans of various types were prepared and were evaluated by tanning tests. The published results helped lay the foundation for the development of present-day satisfactory syntans by industry. An investigation of the tanning properties of sulfite cellulose, a by-product of the paper industry, demonstrated that this material could be used in conjunction with vegetable tanning extracts. Later, during World

[3] *A rapid quantitative analysis of collagen*, NBS Technical News Bull. 40: 65. May 1956.

[4] *Micropores in leather*, NBS Technical News Bull. 39: 68. May 1955.

War II, it was shown that iron could be substituted for chromium during an emergency.

During World War II military and civilian shoe requirements were so great that the tanning industry had difficulty in expanding operations sufficiently to meet the increased demand. Of chief concern were the acute shortages of hides and tannins. Recognizing the need for conservation, the Army Quartermaster Corps sponsored research at the Bureau to improve the stability and serviceability of leather and to develop test methods for military items. The Bureau investigated several oil and wax treatments, which were adopted by the Armed Forces to increase the wear resistance of sole leather.

After the war, research directed toward improving the serviceability of leather was continued. This work aimed not only to increase the wear resistance of sole leather but to improve low-grade hide areas so that more first-quality soles might be cut from the same hide. Ultimately both these objectives were attained by development of a method for impregnating leather with polymers.[5]

The tightly woven condition of the natural fibers of leather tends to limit the materials with which it may be impregnated. Thus, the Bureau's early attempts to use various solutions of commercial polymers as impregnants were not successful, and research was for a time directed toward impregnating the leather with monomers for polymerization *in situ*. Then, as a result of other research on pore-size distribution in leather and particle-size distribution in rubber latex, it became apparent that leather could be impregnated by soaking the crust leather (tanned, but not finished) in solutions of specially prepared or selected commercial polymers. On the basis of these findings, a method of treatment was developed.

Laboratory tests have shown that the treatment increases wear by about 80 percent and reduces water absorption by about half. Since crust sole leather containing a minimum amount of uncombined tannins is used, considerable saving in tanning materials is effected. Furthermore, impregnation may increase the wear of belly and shoulder leather to equal that of high-quality sole leather.

To bridge the gap between laboratory investigation and large-scale industrial application of the process, pilot-plant studies are being conducted at NBS under sponsorship of the Navy Bureau of Supplies and Accounts. These studies have shown that by varying the impregnating process, long wearing leathers can be produced having various degrees of waterproofness, flexibility, and water-vapor transmission. Methods have also been developed for imparting a finished appearance to the impregnated leather.

STABILITY AND SERVICEABILITY

The aging qualities of leather depend principally on its tannage, environment, and use. However, investigations of the mechanism of degradation have shown that highly ionizable acids, either added during manufacture or adsorbed from the atmosphere, are a major factor n leather deterioration.

Over 20 years ago the Bureau made a thorough study of the effect of acid on leather and published a series of papers on the subject. Some of the more important results of this investigation were the development of a standard procedure for determining acidity in leather and the determination of the optimum pH to prevent change in the properties of leather during prolonged storage. Other factors in leather deterioration which the Bureau has studied include temperature, oxygen, moisture, and the catalytic effect of traces of copper and iron salts in the leather.

Before World War II mildew on leather was not considered very important and little effort was made to prevent its growth. However, military forces stationed in tropical areas soon found that the growth of mildew on numerous items of equipage was a serious problem. The Army therefore initiated a project at the Bureau for the development of fungicidal treatments and test methods.[6]

These studies showed that the principal effect of mildew on leather, other than appearance, is the removal of greases, which causes stiffness and loss in strength. As a result of the investigation, a specification for the fungicidal treatment of leather was prepared and quantitative methods were developed for the determination of fungicides in leather. This work has been continued with the development of new fungicides and

[5] *Improved techniques for impregnating leather*, NBS Technical News Bull. 39: 96. July 1955.

[6] *Prevention of mildew on leather*, NBS Technical News Bull. 32: 84. July 1948.

establishment of procedures for reliable evaluation of all fungicidal materials.

TEST METHODS

Much of the Bureau's work on leather has been concerned with the development of new or improved methods or equipment for testing leather and leather products. The results have been used both in procurement specifications and in evaluation and development work.

For many years the accurate determination of moisture in leather was a serious problem to analysts, as the results for all other chemical constituents are expressed on the oven-dry basis. In 1941 NBS research showed that control of the atmospheric humidity in the drying oven would permit moisture determinations to be made with considerable precision. This method has since been adopted as the ultimate standard in Federal Specifications.

Because the properties of leather vary considerably over the area of a hide, it is important that a test sample represent as nearly as possible the average for the hide. Bureau scientists devised a sampling procedure[7] for shoe upper leather that permits selection of sampling locations so that the fewest specimens are required to give the desired accuracy for a particular property. The sampling procedure is based on a mathematical relationship involving the coefficient of correlation between the value obtained for a particular test from a specific location and the average for that test over the corresponding side. The most suitable sampling location on a hide for all tests required in acceptance testing was also determined.

A number of techniques and devices have been worked out for making performance tests of leather products. Much of this work has dealt with water-vapor permeability. Other developments have been concerned with measurement of abrasion resistance, flex life, accelerated aging, and compressibility.

Recently, in work sponsored by the Office of the Quartermaster General, the Bureau has developed a nondestructive method for testing leather, based on the transmission of sound waves.[8] The chief instrument employed is a pulse propagation meter which measures and records the speed of a generated sound pulse through the leather. As a result, the specimen under test is left unharmed, in contrast to the tearing or other destructive effects of other test procedures. Good correlation has been found between sonic measurements and the results of tensile and breaking elongation tests.

FUTURE PLANS

In the near future the Bureau expects to begin a study of leather degradation by radiation. The newly developed technique for amino acid determination will be used in this work. This method of approach should show the exact point of attack in the collagen molecule and thus give a clearer explanation of the mechanism of breakdown.

Recently developed methods for determining particle size of polymers will also be utilized to study the size of particles in tannins and leather impregnants. Comparison of these results with data on leather pore size should not only provide additional information on the mechanism of tanning but should also make possible a better understanding of the nature of the tanned material.

[7] *Sampling of upper leather for shoes*, NBS Technical News Bull. 35: 6. Jan. 1951.

[8] *A sonic technique for testing leather*, NBS Technical News Bull. 40: 35. March 1956.

There are agents in nature able to make the particles of bodies stick together by very strong attractions. And it is the business of experimental philosophy to find them out.—NEWTON

BOTANY.—*Additional Fijian mosses, III.* EDWIN B. BARTRAM, Bushkill, Pa.

(Received September 25, 1956)

The mosses collected by Dr. A. C. Smith on his latest expedition to Fiji, April to December 1953, under the auspices of the Smithsonian Institution and the National Science Foundation, are represented by 136 numbers, many of which are in generous quantity for wide distribution. For the most part the collections duplicate previous gatherings but are of interest from the standpoint of local distribution. Three new species, *Syrrhopodon vitiensis*, *Thyridium parvifolium*, and *Chaetomitrium smithii*, together with a new variety of *Chaetomitrium orthorrhynchum*, a species new to the local flora, and *Thamnium ellipticum*, not previously known from Fiji, are the outstanding features of the series. The list of Fijian mosses now numbers about 288 species of which 75, or approximately 25 per cent, are endemic. Further explorations may expand the list to some extent, but it seems likely that the flora as now known is reasonably complete.

A representative series from this collection is in my herbarium and a complete set in the United States National Herbarium.

FISSIDENTACEAE

Fissidens vitiensis Dix.

Ovalau: Hills east of Lovoni Valley, alt. 300–500 m, dense forest, on rich humus, no. 7361.

Fissidens mangarevensis Mont.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–300 m, dense forest, on rocks along stream, no. 8842. Taveuni: Summit of adjacent slopes of Mount Manuka, east of Wairiki, alt. 700–850 m, dense forest, on caudex of tree-fern, no. 8226. Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest, on caudex of tree-fern, no. 8040.

Fissidens filicinus Doz. & Molk.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on rocks in dry stream bed, no. 8346.

DICRANACEAE

Trematodon longicollis Mx.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on clay banks along stream, no. 8673b.

Campylopodium integrum (C.M.) Par.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on clay banks along stream, no. 8673a.

Campylopus samoanus Broth.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on wet rocks along stream, no. 7122. Ovalu: Summit of Mount Ndelaiovalu and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on wet humus-covered rocks, no. 7573.

Leucoloma tenuifolium Mitt.

Viti Levu: Namosi: Hills north of Wainavindrau Creek, between Korombasambasanga Range and Mount Naitarandamu, alt. 250–450 m, dense forest, on tree trunks, no. 8452.

LEUCOBRYACEAE

Octoblepharum albidum Hedw.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, in masses of humus on trees, no. 7842. Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–400 m, dense forest, on tree trunks, no. 8204.

Leucobryum pentastichum Bry. jav.

Viti levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, in dense mats on decayed wood, no. 8857. Ngau: Hills east of Herald Bay, inland from Sawaicke, on slopes of Mount Vonda (Lion Peak) and toward Waikama, alt. 30–200 m, on humus at roots of trees in open forest, no. 7994.

Leucobryum sanctum Hpe.

Viti Levu: Serua: Hills between Wainingere and Waisese Creeks, between Ngaloa and

Wainiyambia, alt. 50–100 m, dry forest, in dense mats on humus-covered logs, no. 9514. Viti Levu: Namosi: Hills north of Wainavindrau Creek, between Korombasambasanga Range and Mount Naitarandamu, alt. 250–450 m, dense forest, in dense masses on humus, no. 8461.

Leucobryum scalare C. M.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, on wet banks along road, no. 7013.

Exodictyon dentatum (Mitt.) Card. ? poor condition.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on bark, no. 7148.

CALYMPERACEAE

Syrrhopodon mamillatus C. M.

Twelve collections from Viti Levu, Ngau, and Ovalau showing a broad distribution in the local area.

Syrrhopodon smithii Bartr.

Viti Levu: Serua: Hills between Wainiggere and Waisese Creeks between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on tree trunks, mixed with hepatics and lichens, no. 9538.

Syrrhopodon (Calymperidium) vitiensis Bartr., sp. nov.

Laxe caespitosus, caespitibus fuscescenti-viridibus, opacis. Caulis brevissimus. Folia sicca crispatula, humida erecto-patentia, ad 12 mm longa, e basi ovata sensim anguste linearisubulata; marginibus remote denticulatis, in parte superior vaginae sat dense serrulatis; costa valida, excurrente; cellulis laminalibus minutis, rotundatis, diam. circa 5μ, vix incrassatis, marginibus versus 2–3 seriebus bistratosis, cancellinis male definitis. Fructus ignotus.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on tree trunks, no. 7103.

This species evidently has some affinity with *S. subulatus* Lac., but the much smaller lamina cells and the leaf margins closely and sharply serrate at the shoulders and distantly denticulate above are good diagnostic characters.

Thyridium parvifolium Bartr., sp. nov.

Caespitosum, caespitibus laxis, lutescentibus. Caulis repens, ramis vix 1 cm altis. Folia sicca erecta, incurva, humida erecto-patentia, valde undulata, ad 2 mm longa, e basi amplexicaule, oblonga, obtusa, limbata. Limbus folii inferne 8–10 seriatus, fere ad apicem folii productus, superne tenuiter denticulatus vel integrus. Cellulis laminalibus rotundatis, diam. 8–10μ, chlorophyllosis, papillosis, cancellina superne rotundata; costa infra apicem folii evanida. Seta 5–6 mm. longa, tenuis, rubra; theca erecta, oblongo-cylindrica, deoperculata 1.8 mm. longa.

Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on tree trunks, no. 7312.

Slightly more robust than *T. flavum* (C.M.) Fleisch. and obviously distinct in the bluntly obtuse leaves with the hyaline border more pronounced and extending nearly to the apex.

Thyridium luteum Mitt.

Five collections from Viti Levu, Ovalau, and Taveuni. Frequent on most of the larger islands.

Calymperes serratum A. Br.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on tree trunks, no. 8198. Ovalau: Hills west of Lovoni Valley, on ridge south of Mount Korolevu, alt. 400–500 m, dense forest on decayed wood, no. 7660.

Calymperes tahitense (Sull.) Mitt.

Viti Levu: Serua: Hills between Navua River and Wainiyavu Creek near Namuamua, alt. 100–200 m, no. 9007. Viti Levu: Serua: Hills east of Navua River, near Nukusere, alt. 100–200 m, dense forest on tree trunks, no. 9142.

Calymperes tahitense var. truncatum Ther & Dix.

Viti Levu: Serua: Hills between Wainiggere and Waisese Creeks, between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on boulders, no. 9390.

POTTIACEAE

Rhamphidium veitchii Dix.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest on clay banks along stream, nos. 8681, 8673.

Barbula inflexa (Duby) C. M.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, dense forest on rocks along stream, no. 8840a.

BRYACEAE

Brachymenium indicum (D. & M.) Bry. jav.

Viti Levu: Serua: Flat coastal strip in vicinity of Ngaloa, alt. near sea level, on humus-covered rocks in village, no. 9502. Ngau: Hills east of Herald Bay, inland from Sawaicke, on slopes of Mount Vonda (Lion Peak) and toward Waikama, in pockets of humus on bare rocks of open hillside, alt. 30–200 m, no. 7957.

Bryum nitens Hook.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, on rocks along stream, no. 8840.

Bryum greenwoodii Dix.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, on humus-covered rocks in dry stream bed, no. 8338.

RHIZOGONIACEAE

Rhizogonium spiniforme (Hedw.) Bruch forma **samoana** Mitt.

Two collections. Frequent throughout the islands.

Rhizogonium setosum Mitt.

Eight collections from Viti Levu, Ovalau, and Ngau. A common species in the local flora.

BARTRAMIACEAE

Philonotis pilifer Dix.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, on clay banks along stream, no. 8680.

HYPNODENDRACEAE

Hypnodendron subspininervium (C. M.) Jaeg.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on trees, no. 7722. Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on tree trunks, no. 7612. Taveuni: Hills east of Somosomo, west of old crater occupied by small swamp and lake, alt. 660–900 m, dense forest, on tree trunks, no. 8382.

Hypnodendron vitiense Mitt.

Taveuni: Hills east of Somosomo, west of old crater occupied by small swamp and lake, alt. 660–900 m, on rocks along stream, no. 8371.

SPIRIDENTACEAE

Spiridens balfourianus Grev.

Ngau: Slopes of Mount Ndelaitho, on northern spur, toward Navukailangi, alt. 350–500 m, dense forest, on trees trunks, no. 7884.

Spiridens aristifolius Mitt.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, dependent from tree trunks and branches, no. 7726. Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, epiphyte, no. 7371.

Spiridens flagellosus Schp.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on tree trunks, no. 7725. Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Voeux Peak), east of Wairiki, alt. 600–700 m, dense forest, in masses on trees, no. 8278.

ORTHOTRICHACEAE

Macromitrium subtile Schwaegr.

Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest on tree trunks, no. 8052.

RHACOPILACEAE

Rhacopilum spectabile R. & H.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, on decayed wood, no. 8841.

PTEROBRYACEAE

Garovaglia smithii Bartr.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, on tree trunks, nos. 7742, 7827.

Endotrichella graeffeana C. M.

Viti Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on tree trunks and branches, no. 8884.

Euptchium setigerum (Sull.) Broth.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on tree trunks, no. 7724.

Symphysodon vitianus (Sull.) Broth.

Five collections from Viti Levu, Ngau, and Ovalau. A frequent species on tree trunks and branches on the larger islands.

METEORIACEAE

Floribundaria seruginosa (Mitt.) Fleisch.

Viti Zevu: Tailevu: Hills east of Wainimbuka River, in vicinity of Wailotua, alt. 100–150 m, on damp rocks at mouth of cave in dense forest, no. 7236.

NECKERACEAE

Calyptothecium urvilleanum (C. M.) Broth.

Viti Levu: Namosi: Northern slopes of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 450–600 m, dense forest, on decayed wood, no. 8740.

Himantocladium implanum (Mitt.) Fleisch.

Ngau: Hills east of Herald Bay, inland from Sawieke, alt. 300–450 m, dense forest on tree trunks, no. 7753.

Homaliodendron flabellatum (Dicks.) Fleisch.

Taveuni: Summit and adjacent slopes of Mount Manuka, east of Wairiki, alt. 700–830 m, dense forest, in masses on tree trunks, no. 8233.

Thamnium ellipticum (Bry. jav.) Kindb.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, on wet rocks along stream, no. 7862.

New to Fiji. Area: Sumatra, Java, Borneo, Philippines.

HOOKERIACEAE

Distichophyllum vitianum (Sull.) Besch.

Three collections from Ovalau and Taveuni. A frequent local species on dead wood.

Cyclodictyon blumeanum (C. M.) Broth.

Vitu Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on rocky banks along stream, no. 8889.

Callicostella vesiculata C. M.

Ovalau: Valley of Mbureta and Lovoni Rivers, alt. 20–50 m, on roots of *Inocarpus* trees along trail, no. 7673.

Callicostella papillata (Mont.) Jaeg.

Seven collections from Viti Levu, Taveuni, and Ovalau. A common species on decayed wood.

Callicostella papillata var. **brevifolia** Fleisch.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Voeux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8256a.

Chaetomitrium orthorrhynchum (D. & M.) Bry. jav. var. **vitiense** Bartr., var. nov.

A typo foliorum marginibus superne minute denticulatis differt.

Species new to Fiji. Quite distinct from the typical form in the upper leaf margins minutely denticulate instead of sharply serrate. Otherwise, the agreement seems to be complete.

Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest, on tree trunks, no. 8048.

Chaetomitrium (Leiocarpus) smithii Bartr., sp. nov.

Caespitosus, caespitibus laxis, depressis, viridibus. Caulis procumbens, irregulariter pinnatim ramosus, ramis late patentibus, 5–8 mm. longis, parce ramulosis, valde complanatis. Folia ramea patentia, ovato-lanceolata, concava, acuminata, 1.5–2 mm. longa; marginibus erectis, fere ad basin serrulatis; costis binis, bene notatis; cellulis anguste linearibus, laevissimis. Seta 12–15 mm. longa, inferne laevis, superne papillosa; calyptra ubique dense hispida, ad basem longe ciliata.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on bark, no. 7172.

The seta smooth below and weakly papillose above will at once separate this species from either *C. depressum* Mitt. or *C. rugifolium* Sull. The habit is more irregular and less dense than in *C. densum* Dix., the leaves more slenderly pointed and the leaf cells essentially smooth.

LEUCOMIACEAE

Leucomium aneurodictyon (C. M.) Jaeg.

Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on bark, no. 7592; Hills west of Lovoni Valley, on ridge south of Mount Korolevu, alt. 400–500 m, dense forest, on decayed wood, no. 7624.

THUIDIACEAE

Thuidium samoanum Mitt.

Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on decayed wood, no. 7598.

Thuidium cymbifolium (D. & M.) Bry. jav.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Vocux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8258.

ENTODONTACEAE

Campylodontium flavescens (Hook.) Bry. jav.

Viti Levu: Namosi: Valley of Wainavindrau Creek, in vicinity of Wainimakutu, alt. about 150 m, on tree trunks in thickets along stream, no. 8817.

SEMATOPHYLLACEAE

Trichosteleum hamatum (D. & M.) Jaeg.

Eleven collections from Viti Levu and Ngau. Frequent locally and widely distributed in the southwest Pacific.

Trichosteleum boschii (D. & M.) Jaeg.

Four collections from Viti Levu. Not uncommon on decayed wood.

Trichosteleum fissum Mitt.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on tree trunks, no. 8206.

Taxithelium lindbergii (Bry. jav.) R. & C.

Viti Levu: Namosi: Hills east of Wainikoroiluva River, near Namaumau, alt. 50–200 m, dense forest, on decayed wood, no. 8913a. Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on tree trunks, no. 7311.

Taxithelium kerianum (Broth.) Fleisch.

Three collections from Viti Levu, Ovalau, and Taveuni. Rather frequent on tree trunks and decayed wood.

HYPNACEAE

Vesicularia reticulata (D. & M.) Broth.

Viti Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on rocky banks along stream, no. 8889a.

Vesicularia calodictyon (C.M.) Broth.

Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on wet rocks along stream, no. 7299.

Isopterygium minutirameum (C.M.) Jaeg.

Viti Levu: Namosi: Hills east of Wainikoroiluva, near Namaumau, alt. 50–200 m, dense forest, on bark, no. 9050.

Ectropothecium molle Dix.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, dense forest, on wet stones along stream, no. 8792.

Ectropothecium adnatum Broth.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Vocux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8256.

Ectropothecium percomplanatum Broth.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Wailotua, alt. 100–150 m, on damp rocks at mouth of cave in dense forest, no. 7237.

Ectropothecium longicaule Bartr.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, in masses on tree trunks, no. 8188.

Ectropothecium cyathothecium (C.M.) Jaeg.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on tree trunks, no. 8638. Viti Levu: Serua: Hills between Waininggere and Waisese Creeks, between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on decayed wood, no. 9639. Ovalau: Slopes of Mount Korotolutolu, west of Thawathi, alt. 300–500 m, dense forest, on decayed wood, no. 8006.

POLYTRICHACEAE

Pogonatum graeffeanum (C.M.) Jaeg.

Four collections from Viti Levu. A frequent local species.

ENTOMOLOGY.—*New species of* Helicopsyche *from the Western Hemisphere*[1] (*Trichoptera, Helicopsychidae*).

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Extensive collections of material from Mexico and smaller collections from other parts of Central and South America have brought to light several species of the genus *Helicopsyche* which prove to be new to science and are herein described.

The genus *Helicopsyche* is of unusual interest because the larva makes a coiled sand-grain case resembling a snail shell, and these queer cases have aroused the interest of many entomologists. A considerable number of species have been described from various parts of the world, including the West Indies and the Americas, but a moderate number of these descriptions are based only on larvae or females, for which forms we do not yet know adequate specific characters to allow positive identification of material.

The American species show a number of phylogenetic trends which are well marked. All these species have a mesobasal lobe or shoulder on the male clasper. In one evolutionary line this shoulder has become separated from the body of the clasper by a wide, arcuate incision (Figs. 5, 6) and has culminated in the species *incisa* and *quadrosa*. In the other well-marked evolutionary line, the mesobasal lobe first became cushion-like, as in Fig. 8, then developed into a wide process appearing to arise from the extreme base of the clasper, as in Figs. 9 and 10. Accompanying this change of the mesobasal lobe, the apical margin of the clasper became rounded and its posterodorsal portion became expanded to form a curious boomerang-shaped structure (Fig. 10). Successive stages in this line are illustrated by *planata*, *borealis*, and *selanderi*, and the present known culminating species are *vergelana* and *piroa*.

It is a curious fact that all the Old World species also have a mesal process arising from the basal edge of the clasper. The initial inference suggests that these Old World species arose from a form such as *vergelana*. In the Old World species, however, the wing venation is more primitive than in the American forms, and the shape of the body of the claspers suggests that they also arose from a type having claspers more like those found in *extensa* or *dampfi*, as apparently the specialized American forms did also. On this basis there seems no doubt that the New World and Old World forms of the genus represent two separate phylogenetic groups, and that the common ancestor of the two combined the more primitive venation of the Old World forms with a primitive clasper perhaps much like that found in some of the New World forms.

DESCRIPTION OF NEW SPECIES

The species described below are virtually identical in size, color, and general structure, as follows: Length from front of head to tip of folded wings, 6–8 mm; color various shades of medium brown except for the antennae and legs which are chiefly straw colored; sixth sternite of the male bearing a fingerlike process; third, fourth, and fifth sternites of both males and females with a fenestrated network of sclerotized thickenings.

Material treated in this paper is in the collection of the Illinois Natural History Survey, unless otherwise indicated.

Helicopsyche extensa, n. sp.

Male: Genitalia as in Fig. 1. Lateral aspect of ninth segment with moderately wide ventral edge; cercus attached just above lateral apodeme. Tenth tergite moderately long and curved downward apex. Clasper with lateral aspect elongated, bearing a truncate dorsal projection toward the base, and with the apical portion truncate; ventral aspect having a wide mesobasal shoulder at base, the mesal edge of the shoulder bearing

[1] This paper is a joint contribution from the Section of Faunistic Surveys and Insect Identification, Natural History Survey, and the Department of Entomology, University of Illinois.

three straight spines; apical portion beyond shoulder narrow.

Holotype male.—Santa Isabel, Valley of the Cosnipata, Department of Cusco, Peru, December 1951, Felix Woytkowski. *Paratype.*—Same data, 1 female.

Helicopsyche woytkowskii, n. sp.

Male: Genitalia as in Fig. 2. Ninth segment with fairly long ventral margin; cercus attached a short distance above lateral apodeme. Tenth tergite moderately short, with a depression at its base. Claspers with lateral aspect short and regular, with relatively sharp anterodorsal and posterodorsal angles; ventral aspect with the fairly large mesobasal shoulder occupying nearly half the length of the clasper and bearing an irregular row of 5 or 6 stout setae along its mesal edge.

Holotype male.—Santa Isabel, Valley of the Cosnipata, Department of Cusco, Peru, January 9, 1952, Felix Woytkowski. *Paratype.*—Same data but December 19, 26, 1951, and January 1, 1952, 3 females.

The short, regular clasper, combined with the simple mesobasal shoulder will differentiate this species from other described species of the genus.

Helicopsyche dampfi, n. sp.

Male: Genitalia as in Fig. 3. Ninth segment with fairly long ventral margin; cercus attached slightly above lateral apodeme. Tenth tergite long, fairly straight, and tapering to a point at apex. Clasper with lateral aspect moderately long and somewhat rectangular; the anterodorsal corner is produced into a short truncate process, the posterodorsal corner is produced into a moderately sharp point; in ventral aspect, the mesobasal shoulder is relatively large and wide, with a row of stout bristles; from this view the apical portion of the clasper is fairly long, with the dorsal portion curved mesad.

Holotype male.—Finca Germania, Chiapas, Mexico, June 20, 1935, A. Dampf. *Paratype.*—Yepocapa, Mun. Yepocapa, Chimaltenango, Guatemala, April 27, 1948. Elev. 4,800 feet. R. L. Wenzel, 1 female (in the collection of the Chicago Natural History Museum).

Distinctive features of this species are the shape of the apex of the clasper and the broad mesobasal lobe with its cushion of setae.

Helicopsyche truncata, n. sp.

Male: Genitalia as in Fig. 4. Ninth segment with moderately long ventral margin, the cercus inserted very close to lateral apodeme. Tenth tergite short and blunt at apex. Lateral aspect of clasper irregular; anterodorsal corner rounded, posterodorsal corner almost quadrate; ventral margin with the mesobasal lobe projecting as a large triangular process. Ventral view of clasper with basal process appearing narrow but sharp, with an irregular mesal cushion of spines.

Holotype male.—Finca Vergel, Chiapas, Mexico, May 19, 1935, A. Dampf. *Paratypes.*—Same data but May 23, 1 male; same data but May 28, 1 male; Huehuetan, Chiapas, November 9, 1932, A. Dampf, 1 male; Mexico, without definite locality, 8 males.

This species is distinguished from other members of the genus by the triangular and shoulder-like mesobasal lobe, as seen in lateral view.

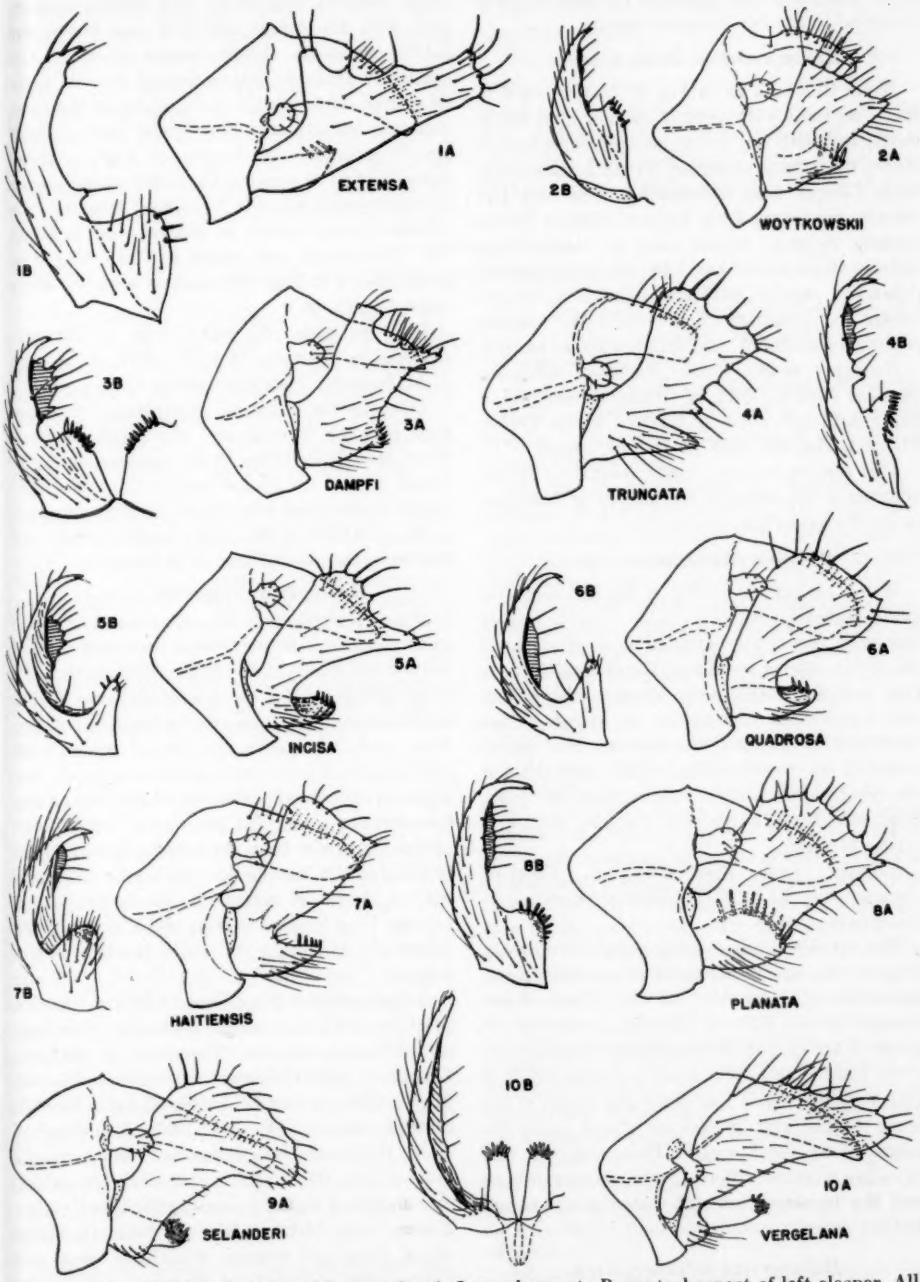
Helicopsyche incisa, n. sp.

Male: Genitalia as in Fig. 5. Ninth segment with moderately long ventral margin, the cercus situated a considerable distance above the lateral apodeme. Tenth tergite of moderate length and sloping gradually to apex. Clasper deeply incised toward the base in such a way that the mesobasal lobe is a narrow mesal projection separated from the main part of the clasper by a wide, arcuate incision; lateral aspect of clasper narrowed above mesobasal lobe, dorsal portion expanded, its anterodorsal corner large and rounded, its posterodorsal corner narrow, elongate and sharp; mesobasal lobe of clasper with a small cushion of short teeth.

Holotype male.—Finca Esperanza, Chiapas, Mexico, May 2, 1938, A. Dampf. *Paratypes.*—Same data but April 4 and April 12, 2 males, and May 30, 1 male; Finca Vergel, Chiapas, May 19–31, 1935, A. Dampf, 7 males; Finca Victoria, Chiapas, May 15, 1938, A. Dampf, 1 male; Mexico (no definite locality), 1 male.

This species forms a small complex with the next (*quadrosa*), the two differing from other members of the genus in having the arcuate incision between the mesobasal lobe of the clasper and the main body of the clasper. In *incisa* the apical margin of the clasper has an excavated area between the two corners, whereas in *quadrosa* the apical margin is evenly rounded.

Both *incisa* and *quadrosa* are probably most closely related to *haitiensis* Banks (Fig. 7), which differs from the two Mexican species in having a narrower but sharper incision between the mesobasal lobe and the body of the clasper. There is



FIGS. 1–10.—Male genitalia of *Helicopsyche*: *A*, Lateral aspect; *B*, ventral aspect of left clasper. All but Fig. 7 drawn from the holotypes.

every indication that *haitiensis* represents a form ancestral to the two Mexican species.

Helicopsyche quadrosa, n. sp.

Male: Genitalia as in Fig. 6. Lateral view of ninth segment with ventral margin moderately short, and with the cercus inserted considerably above the lateral apodeme. Tenth tergite fairly deep. Clasper with mesobasal process long and narrow, separated from body of clasper by an arcuate incision; lateral view of clasper constricted above meso-basal lobe, the dorsal portion expanding rapidly, with a rounded anterodorsal corner, a quadrate and relatively massive posterodorsal corner, and an even apical margin.

Holotype male.—Finca Victoria, Chiapas, Mexico, June 1, 1935, A. Dampf. *Paratypes.*—Same data but June 2, 1 male; Finca Vergel, Chiapas, May 28, 1935, A. Dampf, 1 male.

This species is most closely related to *incisa*, differing in the shape of the clasper as described under the preceding species.

Helicopsyche planata, n. sp.

Male: Genitalia as in Fig. 8. Lateral aspect of ninth segment with fairly wide ventral margin and with the cercus situated a short distance above the lateral apodeme. Tenth tergite fairly long and moderately deep. Clasper with lateral aspect somewhat rectangular, its apical portion moderately expanded, the anterodorsal corner rounded, the posterodorsal corner pointed but not greatly produced; in ventral view the mesobasal lobe forms a rounded shoulder bearing a cluster of spines.

Holotype male.—San Cristóbal, Chiapas, Mexico, July 7, 1926, A. Dampf. *Paratype.*—Same data, 1 male.

This species is most closely related to *borealis* (Hagen) on one hand and the *mexicana-arizonensis-limnella* complex on the other. From *borealis*, *planata* differs in the sharp posterodorsal corner of the clasper, the less bowed dorsal margin of the clasper, and in the short aedeagus, which in *planata* is one and a half times the length of the tenth tergite and in *borealis* about twice the length of the tenth tergite. From *mexicana* and its allies *planata* differs in the narrower apex and the regularly rounded anterodorsal corner of the clasper.

Helicopsyche selanderi, n. sp.

Male: Genitalia as in Fig. 9. Lateral aspect of ninth segment with fairly wide ventral margin, and with the cercus attached just above the lateral apodeme. Tenth tergite elongate and relatively shallow. Lateral aspect of main body of clasper fairly narrow and angular at the base, tapering toward apex, the apical portion itself greatly enlarged and forming a large, rounded posteroapical expansion; the anterodorsal corner is evenly rounded; the mesobasal lobe forms a tubular process which in ventral view is about the same width and about half the length of those shown in Fig. 10*B*, capped with the same cluster of spines.

Holotype male.—20 miles west of Morelia, Michoacán, Mexico, July 19, 1955, R. B. and J. M. Selander. *Paratype.*—Same data, 1 male.

This species forms an interesting annectant step between *borealis* and the *piroa* complex. From *borealis* it differs in the produced posterodorsal area of the clasper and in the well differentiated mesobasal lobe. From the *piroa* complex, *selanderi* differs in the wider basal portion and shorter posterodorsal area of the clasper.

Helicopsyche vergelana, n. sp.

Male: Genitalia as in Fig. 10. Lateral aspect of ninth segment with the ventral portion unusually narrow and small, and with the cercus attached a short distance above the lateral apodeme. Tenth tergite moderately long and moderately shallow. Main body of clasper with lateral aspect small and narrow at base, expanding toward apex into a greatly developed posterodorsal lobe; mesobasal lobe forming a long flat process, in ventral view appearing to rise from the extreme mesal corner of the base of the clasper; each lobe is capped with a cluster of spines. In the holotype this process is as long as in Fig. 10; in some of the paratypes it ranges to only two-thirds this length.

Holotype male.—Finca Vergel, Chiapas, Mexico, May 30, 1935, A. Dampf. *Paratypes.*—Huehuetan, Chiapas, Mexico, November 9, 1932, A. Dampf, 1 male; Chipitlan, Cuernavaca, Mexico, May 3, 1941, A. Dampf, 1 male; Rancho Monter, Oaxaca, Mexico, Dec. 14, 1937, A. Dampf, 1 male; Hacienda Vista Hermosa, Villa Santiago, Nuevo León, Mexico, June 16, 1940, Hoogstraal and Knight, 5 males, 3 females; Sabinas Hidalgo, Nuevo León, Mexico, June 16, 1939, H. Hoogstraal, 4 males, 2 females. Additional larvae and pupae were collected by Harry Hoogstraal on rocks in a spring at the last locality.

This species is most closely related to *piroa* Ross, from which it differs in the typical narrow process of the sixth sternite, the shallow tenth tergite and the narrower and usually more elongate mesobasal process of the clasper. In *piroa* the ventral process of the sixth sternite is wide and flat, forming a broad flap; the tenth tergite is deep and bears a ridged hump at the base; and the mesobasal process is only slightly longer than that in *selanderi*, but much wider than in *vergelana*.

The above material from the vicinity of Nuevo León was previously considered as belonging to *piroa* and was included in the original description of that species. More critical examination of differences instigated by the discovery of *selanderi* has led to a more critical diagnosis of these forms.

SMALL ARMS AND AMMUNITION

The American Revolution might have been fought—on the side of the colonies—with bows and arrows. They still were better weapons, in some respects, than the available muskets of the day—as emphasized by Benjamin Franklin in a 1776 letter to Gen. Charles Lee, who then was engaged in fortifying the port of New York:

> These were good weapons, not lightly laid aside: Because a man may shoot as truly with a bow as with a common musket. He can discharge four arrows in the time of charging and discharging one bullet. His object is not taken from his view by the smoke of his own side. A flight of arrows, seen coming upon them, terrifies and disturbs the enemies' attention to their business. An arrow striking in any part of a man puts him hors-du-combat till it is extracted. Bows and arrows are more easily provided everywhere than muskets and ammunition.

This is cited by Col. Berkeley R. Lewis, of the Frankfort Arsenal, Philadelphia, in a comprehensive treatise[1] on small arms and ammunition, especially as used in the United States military service, which has just been published by the Smithsonian Institution.

There was a good deal to be said for Franklin's position for, after more than four centuries, firearms still were in a rather primitive stage and, even such as they were, the colonies were poorly equipped to produce them. Just when firearms first were used in battle is somewhat debatable, Colonel Lewis points out. Artillery was used first. Some cannon were made in Italy around 1312. They were stone-throwing mortars.

The first hand firearms were crude iron or copper tubes, fired by applying a live coal to a touchhole. This was a shallow cup at the top of the breech, whence a small hole led downward into the powder chamber. This device usually—not always—fired the charge.

Most of the trouble with firearms during the succeeding 500 years was due to this ignition system. All this time at least one misfire could be expected in ten shots.

The first pistols, known as "bombardelles," appeared in Italy about the middle of the fourteenth century. The barrels were 9 inches long. In 1544 French cavalry were armed with "pistols" whose barrels were 25 inches long.

Hand cannon were brought to England in 1471. This weapon, weighing between 60 and 70 pounds, was carried by two men. It was difficult to load and uncertain in range and accuracy—quite inferior to the crossbow or longbow then still in use.

Early in the fifteenth century Spaniards invented the arquebus with a matchlock trigger mechanism. It was probably inferior to the longbow in battle. About 1521 Spanish inventors produced the "mousquet," musket. It was 6 to 7 feet long, weighed 60 to 70 pounds, and was very slow in loading. The oldest rifles date from the end of the fifteenth century. At first they were considered purely as sporting weapons.

When the first settlers came to North America they brought with them the firearms then in use in Europe. There were local gunsmiths, but most of them were engaged in repair of arms, and rebuilding of weapons damaged beyond repair, by combining parts of two or more. At the start of the Revolution the only military arms of any consequence in the hands of the colonists were the European weapons left over from the French and Indian wars. During the war anything that would shoot was pressed into service. Small local manufactures were expanded, however, and new ones started under patronage of the various colonies.

From this point Colonel Lewis traces the evolution of small arms through the various American wars up through the Civil War.

[1] *Small arms and ammunition in thd United States Service* [1776–1865], by Col. BERKELEY R. LEWIS, 338 pp., 52 pls. Smithsonian Institution, Washington 25, D. C. $8.00.

MAMMALOGY.—*A new species of murine opossum (genus* Marmosa*) from Peru.*

CHARLES O. HANDLEY, JR., U. S. National Museum.

(Received September 4, 1954)

Mammals collected by representatives of the Pan American Sanitary Bureau during investigations of plague in Peru and Ecuador are being studied in the U. S. National Museum. Among these specimens are two murine opossums (*Marmosa*) from the western flank of the Andes in central Peru which are strikingly different from other named forms. They are the northernmost representatives of a group that includes the species *elegans*, *janetta*, *marmota*, and *pusilla*, inhabiting parts of Chile, Argentina, Bolivia, and Paraguay. The place of capture is almost a thousand miles northwest of the known range of their nearest relative.

For the opportunity to study these specimens, which have been deposited in the National Museum, I am indebted to Dr. Fred L. Soper, Director, and Dr. E. C. Chamberlayne, adviser, Communicable Diseases Branch, Pan American Sanitary Bureau, Washington, D. C. I am also grateful to Dr. Philip Hershkovitz, Chicago Natural History Museum, for the loan of comparative material of *M. janetta* and *M. marmota*.

This animal is named in honor of the late George H. H. Tate, whose revision of the genus *Marmosa* (Bull. Amer. Mus. Nat. Hist. **66** (1): 1–250, 1933) went far toward bringing order to an extremely complex group.

Marmosa tatei, n. sp.

Holotype.—U.S.N.M. no. 302915; adult male, skin and skull (skinned from alcohol); collected December 1955, by José Maria de la Barrera; Chasquitambo (710 m, lat. 10° 18′ 48″ S., long. 77° 37′ 20″ W.), Ancachs, Peru; original number 53/139.

Distribution.—Known only from the type locality.

Description (of holotype; coloration possibly slightly altered by 3 months immersion in alcohol; capitalized color terms from Ridgway, 1912, *Color standards and color nomenclature*).—Fur long (12 mm on rump, 8 mm on anterior abdomen) but not woolly or wavy; mass effect of dorsum between Benzo Brown and Fuscous, rather sharply distinguished from sides, which are Mouse Gray, washed on mid-flanks with Drab; dark dorsal patch extends forward as a thin line to snout; flank color extends on dorsal surfaces of forearms and legs to wrists and ankles; face much paler than dorsum or flanks, about Drab-Gray; black eye-ring prominent, 2 mm wide around eye and extending 4 mm behind and 8 mm in front of eye; longest labial vibrissa 33 mm; ears dark gray, long and broad; antihelix large; spina helicis not lobed; underparts white, hairs gray-based toward sides; throat gland large; feet and hands small, pure white; claws short (2 mm); external anterior and posterior pads of hind foot separate; pads between second and third and third and fourth hind toes subequal, the latter slightly smaller; tail relatively short, incrassated (about 8 mm thick near base before skinning), basal two-thirds sharply bicolor (Fuscous-Black above, white below), distal third whitish, extreme tip (13 mm) pure white; body-fur extends only 5 mm on base of tail; scales of tail in annular arrangement, about 32 rows per centimeter at base.

The paratype, U.S.N.M. no. 302916, a young adult by Tate's scale (*op. cit.*), is similar to the holotype in coloration but is slightly brighter. Its tail is very sharply bicolor proximally, the dorsal portion being almost black; the distal 10 mm are pure white.

Skull strong, heavily built, and relatively angular; nasals slightly expanded anterior to frontomaxillary suture, acute posteriorly; interorbital region broad anteriorly, tapering to narrowest point at "postorbital constriction" of Tate (*op. cit.*); supraorbital ridges indistinct, forming slight triangular postorbital prominences, continuous with temporal ridges which converge to form a low crest on frontals, parietals, and interparietals, where they merge with prominent lambdoidal crests; braincase narrow; zygomata thick and heavy; palate in the younger specimen exceedingly fenestrated, in the adult less so but still with large posteroexternal vacuities; posterior margin of palate produced into a thick wall 7 mm high, recurved over palate; "palatal

bridge" (alisphenoid-ethmoid portion of basicranium) long and very narrow; auditory bullae relatively far apart, large, and attenuated anterointernally into pointed processes.

Canine strong (crown of upper canine measuring 3.3 mm in height from alveolus); P^2 without distinct cingulum; P^3 higher and longer than P^2; molars relatively broad (crown of M^4 in transverse diameter 2.4 mm.

Measurements (of holotype, in millimeters, taken according to Tate's directions (*op. cit.*)).—Basal length 30.7, greatest length 33.4, zygomatic breadth 17.9, palatal length 17.7, least breadth across pterygoid wings of alisphenoids 2.0, breadth of auditory bulla 3.5, greatest breadth across auditory bullae 10.5, greatest breadth across styliform processes of petrosals 8.8, greatest length from anterior wall of auditory bulla to posterior border of petrosal 5.8, greatest breadth of palate across outer corners of M^3 9.6, maxillary tooth row (M^{1-3}) 5.1, greatest length of nasals 14.2+, greatest breadth of single nasal 1.5, breadth of postorbital constriction 5.0, breadth of braincase 12.2. Head and body 123, tail vertebrae 132, hind foot 16, ear from notch 22, greatest breadth of ear 19.

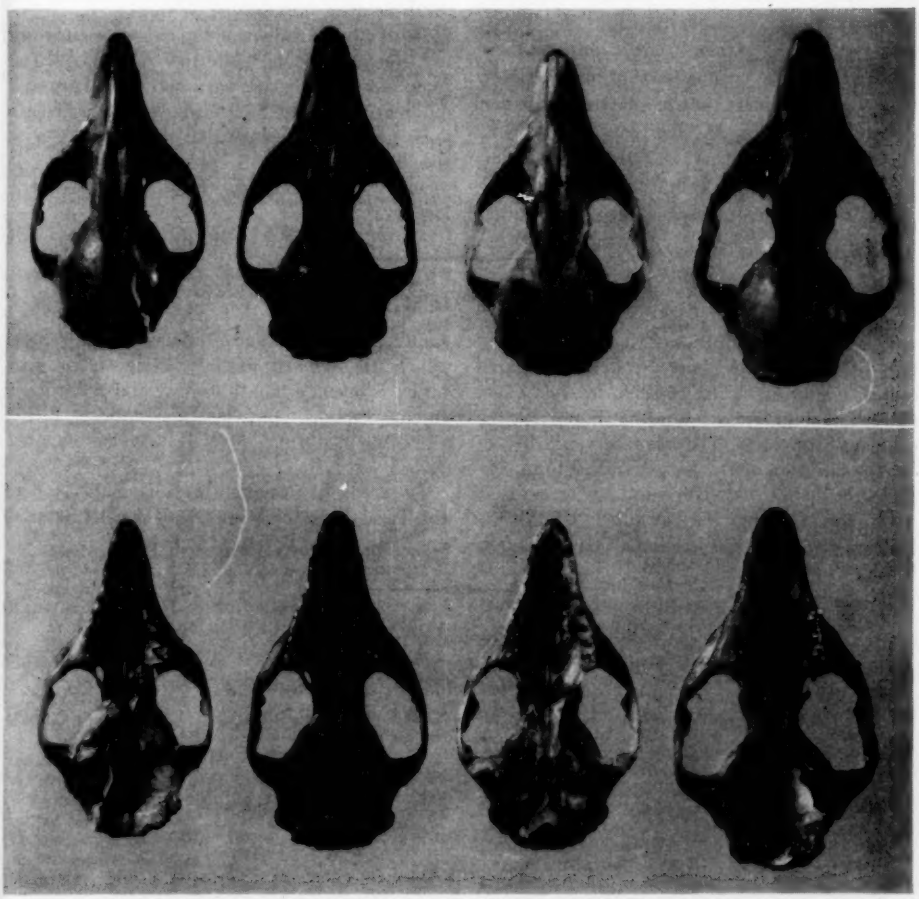


Fig. 1.—Skulls of *Marmosa tatei* and its relatives. Upper row, dorsal aspect; lower row, ventral aspect; left to right: *M. elegans*, Guillermo Mann 101; *M. tatei*, U.S.N.M. no. 302915; *M. janetta*, C.N.H.M. no. 50973; *M. marmota*, C.N.H.M. no. 26760.

Comparisons.—Sharply defined dorsal and flank colors; large ears; small hands and feet; short, thick tail with annular arrangement of scales; slightly expanded nasals; highly fenestrated palate; long, narrow palatal bridge; large auditory bullae; and large P^3 stamp *M. tatei* as a member of the *Marmosa elegans* group. Large size, narrowed postorbital region, narrow braincase, and convergent temporal ridges relate it to the *elegans* section of that group (Fig. 1).

Numerous characters distinguish *M. tatei* from all other members of the *elegans* section: Dorsal coloration grayer, tail more extensively white tipped, nasals more expanded anterior to frontomaxillary suture and more acute posteriorly, temporal ridges converging to form a more prominent sagittal crest, palatal bridge narrower, canines longer, and molars relatively broader. It most resembles *M. marmota* of southern Paraguay (C.N.H.M. no. 26760) but is smaller, and has a narrower skull, less distinct supraorbital ridges (thus interorbital region smoother and less angular), a more extensive eye-ring, and whiter underparts. *M. tatei* is similar in size and proportions to *M. janetta* of southern Bolivia (C.N.H.M. 29169, 29170, 50972, and 50973), but otherwise is distinguished by having underparts whiter, auditory bullae larger; P^3 larger; interorbital region broader anteriorly, narrower posteriorly, not constricted before postorbital process, and lacking prominent supraorbital ridges. *M. tatei* is more remotely related to *M. elegans* of Chile (U.S.N.M. nos. 1705 and 269806), from which it differs in having whiter underparts, blacker, more extensive eye-ring; much more heavily ossified skull; and interorbital region much broader anteriorly.

Remarks.—Members of the *elegans* section are widespread, seldom collected opossums. The forms *marmota*, *janetta*, *tatei*, and *elegans* are well differentiated, but collecting in intermediate areas might show some or all of them to be conspecific.

Specimens examined.—Two from the type locality.

NEWS OF MEMBERS

The International Business Machines Corporation has announced plans for a new research center, employing 1,600 persons, to consolidate all fundamental research aimed at improving the company's products. The laboratory will be under the direction of Dr. EMANUEL R. PIORE.

GEORGE GAMOW was awarded UNESCO's Kalinga prize for 1956 in recognition of his outstanding interpretation of science to the general public. He received £1,000 sterling and an invitation to spend a month visiting and lecturing in India.

DONOVAN S. CORRELL has joined the staff of the Texas Research Foundation as chief botanist and head of the Botanical Laboratory.

Man's work must ever end in failure,
Unless it bears the stamp of mind.
The head must plan with care and thought,
Before the hand can execute.—SCHILLER

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